INVESTIGATION OF THE EFFECTS OF CURRICULUM CHANGE ON THE DEVELOPMENT OF CAL IN BTEC NATIONAL AND HIGHER NATIONAL CERTIFICATE/DIPLOMA COURSES IN ELECTRICAL AND ELECTRONIC ENGINEERING.

by

DENNIS HEATH

A Master's by Course Dissertation submitted in partial fulfilment of the requirements for the award of the degree of MSc in Computer Education of Loughborough University of Technology, January 1990.

Supervisor: Mr P.K.Armstrong

ABSTRACT

INVESTIGATION OF THE EFFECTS OF CURRICULUM CHANGE ON THE DEVELOPMENT OF CAL IN BTEC NATIONAL CERTIFICATE/DIPLOMA AND HIGHER NATIONAL CERTIFICATE COURSES IN ELECTRICAL AND ELECTRONIC ENGINEERING

The Haslegrave Report of 1969 led to major curriculum curriculum developments in technician education courses in further education. These were in the form of Technician Education Council (TEC) and Business Education Council (BEC) (later to be amalgamated to form Business and Technician Education Council (BTEC)) initiated Ordinary and Higher National Certificate/Diploma courses. The changes within the new Electrical and Electronic Engineering Technician courses were greatly enhanced by the impact of the 'New Information Technology Revolution.' Together they highlighted the need for a greater flexibility in technician education. A great emphasis has been placed on the students learning by doing. This places a major emphasis on the use of a wide range of resources to fulfil such a strategy. One such resource which could have significant application to the above approach to learning is Computer Assisted Learning. However, at present there is little documented evidence of its wide use in Electrical and Electronic Engineering BTEC courses.

This work attempts to investigate the impact that the above mentioned curriculum changes have had on CAL development within the above mentioned course.

In order to form an overall impression, models of learning and the various learning and teaching styles are examined to identify their possible application in the development and evaluation of effective CAL courseware/software in such courses.

Along with this a survey of staff from eight colleges in BTEC Electrical and Electronic Courses was carried out, and observational studies of CAL usage in the classroom. The purpose of such investigations was to build up a picture of the present state of CAL usage and development within the curriculum changes that have taken place.

Future developments in the area of CAL are outlined and overall conclusions drawn from the results of the investigation.

KEYWORDS: CAL, BTEC, ELECTRICAL AND ELECTRONIC ENGINEERING COURSEWARE, SOFTWARE, INFORMATION TECHNOLOGY

ACKNOWLEDGEMENTS

In attempting a work of this nature, with the trials and tribulations one encounters along the way, much support and encouragement is needed.

Therefore, in submitting this dissertation I would like to express my sincerest thanks and appreciation to the numerous people who have helped to make it possible.

All the staff of the colleges who took part in the survey and, their respective Heads of Department for allowing me access to their staff. My colleagues in the 'electronics team' for their continued support, advice and friendship. Mr. Armstrong my supervisor for his encouragement, advice and support throughout the project, willingly given.

My mother and in-laws for their encouragement.

Above all this work is dedicated to my wife Barbara and children Lisa and David for their devotion and understanding throughout, and in particular to my wife for the preparation of this manuscript.

DECLARATION

I declare that the following thesis is a record of work carried out by me, and that the thesis is my own composition.

Dennis Heath

January 1990.

CONTENTS

PAGE

PAGE

TABLES

FIGURES

PAGE

PAGE

PAGE

PAGE

CHAPTER 1

INTRODUCTION

1.1 General

The use and development of Computer Assisted Learning (CAL) in the primary and secondary sectors of education has been well publicised and documented (vide Infra 1.3). However, in Further Education the picture is a far more sketchy one.

Dramatic changes have taken place over the last twenty years in technician education following the Haslegrave Report see DES (1969), resulting in the setting up of the Technician Education Council (TEC) and Business Education Council (BEC) (later to be amalgamated to form the Business and Technician Education Council (BTEC), which have initiated National and Higher National Certificate/Diploma courses in Business and Engineering sectors of Further Education.

With the above factors in mind as well as the rapid developments in Information Technology this work has set out to identify the effects of these curriculum changes on the development of CAL in BTEC courses in Electrical and Electronic Engineering. This objective has been investigated, using as its main vehicle the questioning of lecturers at a number of further education institutions on various issues related to CAL and the observation of students and lecturers working within a CAL environment.

Chapter 1 - This examines the historical developments of CAL, and the subsequent developments in CAL within the British Education system. The major aims of the work are also detailed.

Chapter 2 - This outlines the models of curriculum change and the agents of change, and relates these to the developments that have taken place in technician courses in Electrical and Electronic Engineering. A discussion of how these changes may affect the development of CAL is also included.

Chapter 3 - Considers the theories of learning and the subsequent models of learning which can be related to the development of CAL courseware.

Chapter 4 - Examines the different learning and teaching strategies and the matching of these to optimise the learning process. Student Assessment methods are also discussed. The various teaching methodologies are discussed to illustrate the place of CAL within the particular teaching strategies and the relevance of these to it .

Chapter 5 - Computer Assisted Learning is clearly defined and its scope outlined along with the use of the computer as a teaching /learning resource. The various modes and types of CAL are identified and related to the learning models in assessing their use as development and evaluation tools. Typical design and evaluation procedures for CAL are discussed and the future development of it.

Chapter 6 - This outlines the methodologies used in the survey of CAL in Electrical and Electronic Engineering courses. Three case studies are examined:-

1) Interview of college staff involved in BTEC courses.

2) Study of students involved in a CAL environment based subject area.

3) Observation of staff and students working with designated software packages.

Chapter 7 - The various observations and views established during the work are drawn together to produce final comments on the overall situation and the future outlook.

1.2 Historical Background

The United States of America in the 1950's was probably the first country to study the instructional uses of the computer. The early foundations for CAL lie in the developments that took place in programmed instruction and the associated use of mechanical teaching machines.

Skinner(1961) originated the technique of programmed instruction borne out of the principles of operant conditioning, with which he is associated. This work on programmed instruction proposed that the best way of tackling a learning task was to break it down into a series of small subtasks and then tackle each one of these in turn. As a means of reinforcing learning, student mastery of a subtask would be rewarded in an appropriate way. On successful completion the student would be encouraged to tackle the next one. If difficulty with a subtask was encountered the learner's progress would be impeded until the necessary level of attainment had been achieved. This was effected by means of extra help and tuition - in other words remediation. This type of programming was termed linear programming and in the form of YES/NO answers on the early teaching machines. In contrast to this was the branching form of programming. It was Crowder (1959) who developed this approach and wrote that :-

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

Whilst the basic belief that student's 'learned by being told ' remained, the emphasis was now on the exposition itself being sensitive to the requirements of the student at all times, with the implication that this sensitivity demanded an analysis of the students actual responses. This form of programming often called intrinsic programming served to cater for a more applicable approach to different student abilities via its branching type approach to different responses. The early type of programs on the teaching machines following Crowder's approach were in the form of Multiple Choice questions.

In contrast to this Computer Assisted Learning offered a greater flexibility. A computer may be programmed to 'understand' a wider range of responses from the student terminal.

The earliest CAL program, see Rath (1959) is thought to have been developed at IBM in the late 1950's. It was part of a project concerned with basic psychological research into memory and learning. The use of the computer, as an automated teaching machine, dominated educational applications of computing in the early 1960's. The supporting courseware for such applications was based upon similar techniques used in programmed learning tests.

An example of note, see Bunderson and Dunham (1968), of an early computer system developed for instructional applications was the IBM 1500 instructional system. It was a joint project between IBM and Stanford University and probably the first CAL system to integrate multi - media learning techniques. Incorporated into the system was a central processing unit (CPU), with bulk storage of data on magnetic tape and exchangeable discs, a station controller, range of peripheral devices including a card reader and line printer. The student terminal consisted of a cathode ray tube (CRT), a keyboard and a light pen which enabled the student to make responses by touching the screen of the CRT. There was also an image projector having a capacity of 1000 slides which could be randomly accessed under computer control plus a set of earphones and a microphone to complete the multi-media resources available. Audio messages via a bank of audio tape devices could be played to the student, being randomly accessed under computer control. These resources could be augmented by filmstrips and reference to textbooks and other conventional learning media.

The above system was used on projects at the elementary level of teaching which began at Stanford University in 1965 under the direction of Patrick Suppes.

Another important historical development occurred in 1960. A committee was formed at the University of Illinois, with the brief to consider the possibility of using computers in teaching of psychology education and engineering. No agreement was however reached. Bitzer (1976) evaluated the committee's report and recommended the following action :

> 'that the computer should be used initially for sorting and tracking student's pedagogical behaviour.'

Subsequently an attempt to teach computer programming was initiated. Bitzer et al (1962) outlined work which formed the basis of the first PLATO CAL system outlined briefly in the following paragraphs.

The early types of CAL system were almost all based on the use of a large time-shared computer system either a mini-computer or a mainframe. To this was attached a number of student terminals or workstations. There was thus a one-to-many relationship between the computer and the student base that it supported. Typical examples of this approach to the provision of CAL facilities include two major American initiatives financed by the National Science Foundation of America (NSF) detailed as follows :-

1) That outlined by Bitzer (1976), the PLATO system (an acronym for Programmed Logic for Automatic Teaching Operation) at the University of Illinois, the development of which was sponsored by the Control Data Corporation.

2) Merrill (1980) describes the TICCIT system (Time - shared Interactive Computer Controlled Information Television) that was produced by the Mitre Corporation.

The third example shown below is an early British initiative set up by the government.

3) Hooper and Toye (1975) outline the various projects sponsored by the National Development Programme in Computer Assisted Learning (NDPCAL). This initiative is discussed further in section 1.3.

Both 1) and 2) were approaches to CAL based on the large main frame computers. Although this mode of CAL implementation has led to many very successful projects,in general, this approach can often be thwarted by a number of significant limitations :-

1) the relatively high cost of this type of computer system.

2) the questionable reliability of the hardware.

3) the low overall availability of the CAL system.

4) the easily degraded performance.

5) the limited interaction environment that is normally available.

An alternative approach to the use of larger machines is the use of small computers in particular the utilisation of micro-systems and personal computers. Indeed, the arrival of this type of computational resource in the 1970's brought about an explosive revival of interest in CAL after the somewhat disappointing experiences with it on large machines as outlined earlier.

The distinguishing feature about a micro or personal computer is the fact that there is a one-to-one relationship between the computer and the student. This enables a more interactive environment allowing the student more control of the situation.

O'Shea (1983) identifies and summarises the various approaches to CAL in the 70's see Table 1.1 Appendix 1.

1.3 CAL in Schools

The initial impact of computer assisted learning (CAL) came in Europe with the promotion of government financed national projects. One of the first on an any scale was the French National Experiment in Educational Computing begun in 1970. It was aimed in the main at secondary education. An important facet of this project was the provision of intensive in-service training courses in computing and CAL for a nucleus of teachers. Once they had been trained it was intended that these teachers should then produce courseware and disseminate it to their colleagues in other parts of the country. Similarly within the United Kingdom the widespread development of CAL was first proposed when the government set up the National Development program in CAL (NDPCAL) in 1973. O'Shea and Self (1983) defined its aims as follows :-

> 'to develop and secure the assimilation of computer - assisted and computer - managed learning on a regular institutional basis at reasonable cost.'

During its 'lifespan' an assortment of twenty-nine projects were supported, involving some 700 teachers in forty-nine different institutions, with a bias towards science teaching in the tertiary sector of education as outlined in Hooper (1977). By 1977 it had aimed to put CAL into a number of institutions to provide funding beyond 1977. However its rather dated programs and the introduction of graphics ensured this did not take place.

The major start came in 1980 when the Microelectronics in Education Programme (MEP) was initiated under the Directorship of Richard Fothergill. Its purpose as a five year 'pump priming' funding to get schools started, had a twofold aim as outlined by Anderson (1985) :-

> '1) that children should understand new technology and its use in and effect on society.
>
> 2) that teachers should be encouraged to make use of technology to improve effectiveness of teaching.'

This was closely followed by the Department of Trade and Industry's (DTI) 'Micros in School Scheme' which Linn (1985) outlined as follows :-

> 'Under the scheme, secondary school teachers had to choose either an RML 380Z or a BBC Acorn microcomputer. This selection of microcomputers was justified on the grounds of their British manufacture'.

In 1982 this scheme was extended to the primary sector. Alongside these developments the BBC Computer Literacy Project was introduced in 1982 with the aims of introducing interested adults and younger students to the world of computers and computing, and to provide the opportunity for viewers to learn, through direct experience, how to program and use a microcomputer. The series was based around the Acorn BBC computer which was being supplied to schools.

This was complementary to the work being undertaken by MEP.

A major influence on information technology and CAL since its inception in 1967 has been the Council for Educational Technology (CET). It is the central organisation for promoting development and application technology at all stages of education and training throughout the U.K. CET advises other bodies, initiates and helps in development programmes in all sectors of education and training, including CAL and the development of computer -controlled media cataloguing, CET along with the Open Learning Federation was at the forefront in promoting open learning in the U.K. Vincent and Vincent (1985) outlined its role in I.T in the following terms :-

> 'CET has a major development programme on I.T; but, increasingly I.T is seen as having implications for every aspect of CET activity, including its own organisations ways of working. New information technology generates much activity which the CET believes is a major ingredient in learning; thus harnessing provision and organisation of educational opportunities is one of CET's concerns. It provides advice and guidance on implementing and integrating I.T into existing teaching methods.'

Among its main areas of interest are Videotex, Telesoftware, Teleconferencing, Interactive Video, Cable, Administration/Management Information Skills, Equipment

Standards, Training, and of course Microcomputers, where its main areas of association have been - responsibility for Microelectronics Education Programme (MEP) accounts and publishing. Also with applications of microelectronics in special education. It has established a network of regional information centres. CET had been involved in a feasibility study looking into the idea of a National Microelectronics Database. STATUS a powerful management database developed by the Atomic Energy Authority was set up as a trial database.

DES (1984) issued a circular which outlined the Education Support Grants Scheme with the aim to encourage Local Education Authorities to redeploy a limited amount of expenditure into activities which appeared to the Secretary of State to be of particular importance. The programme has three parts, hardware, staff development and courseware. It was aimed to assist authorities in providing for students studying vocational subjects, which take account of the increasing use of information technology in the world of work; not just those associated with computing technology. The effect being to enable the students to become sufficiently knowledgeable and skilled in I.T. The support grant was made available to schools, universities and colleges of further education. In the latter case it was aimed at extending the awareness of I.T into Non-Advanced Further Education (NAFE).

In 1986 the Micro-Electronics Programme came to an end and was replaced by the Microelectronics Support Unit (MESU). MESU (1987) outlines the main tasks given to the unit as being :-

1) to provide curriculum materials which will help teachers use the computer across the curriculum where appropriate.

2) to provide an information service that informs about such things as available software and hardware; curriculum materials; examples of good practice; conferences and training opportunities and curriculum development work in hand (and anything else that we are told might be useful).

3) to support in any way possible the activities of the pre-and in-service trainers.

4) to continue and develop the work begun by MEP in Special Education.

In April 1988 MESU was amalgamated with CET to form the National Council for Educational Technology (NCET).

NCET (1989) defined the objectives of the National Council as :-

'To support, encourage, promote, develop, apply and maintain, the use of learning systems and new technologies (including microcomputers, electronic systems and other aspects of information technology) to all aspects of education and training in all part of the United Kingdom; the focus to be on the learning process.'

During the period of these developments three major programming languages emerged to provide important connotations for the future.

In 1967 Bolt, Beranek and Newman devised a problem solving programming language called 'LOGO", subsequently developed at the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology. According to Papert (1973):

> 'the theory underlying this work draws on ideas from the Piagetian tradition of thinking about children and from those aspects of artificial intelligence concerned with thinking in general.'

Piagetian thinking led Papert with the aid of LOGO to create a unique learning environment via the medium of the microcomputer. In 'Mindstorms' Papert (1980) he places the emphasis on children discovering knowledge through the exploration of 'computer microworlds.' Goldenburg (1982) defined these as:-

> 'a well defined but limited, learning environment in which interesting things happened and in which there are important ideas to be learned.'

These important ideas are analogous to Papert's 'powerful ideas' which are essentially cognitive skills valued by society.

The LOGO language is widely available for BBC and RM machines, microcomputers marketed as 'LOGOTRON'. The software plus the use of the 'LOGO TURTLE' have been used in a number of primary schools to good effect, though perhaps not on as wide a basis as one might have expected.

Clocksin and Mellish (1981) outlined the development of 'logic programming' in particular the language PROLOG which is essentially a notation for predicate logic. It is a language which has applications in artificial intelligence /expert system technology and is the language currently being used in the Japanese 5th Generation Computer Project see FEU (1989).

It has been claimed that among the main advantages of PROLOG is that it enhances logical thinking whereas LOGO improves problem solving strategies.

Another important language that came to the fore during the 70's and 80's was SMALLTALK evolved around the late 60's early 70's. In the early years SMALLTALK was envisaged as a medium for school age pupils to acquire extensive programming skills. In 1970 the designers encouraged by the work on LOGO were as Kay and Goldberg (1977) mention:

'interested in focusing on children as our user community.'

By 1976 it is regarded as a communications medium for children of all ages. In 1981 it was clear that the SMALLTALK-80 system was not a language for children. Goldberg and Ross (1981) referring to it instead as:

'focuses more on software development for the professional.'

Today it is very much regarded as an author language offering possibilities in the area of artificial intelligence.

Despite these and the earlier initiatives in promoting the development of Information Technology and Computer Assisted Learning there have still emerged major criticisms concerning both the hardware and software provisions in the area of CAL. The following comments are typical of such criticisms.

Coburn (1982) implies that:-

'there is widespread agreement that the state of the art of educational software development leaves much to be desired.'

Braun (1981) considers that:

'Much of it is poorly programmed and/or pedagogically inadequate.'

Hawkridge (1983) states:

'Critics of new information technology point out, with some justification that the courseware available so far for use in the new machines is inadequate in quality, quantity and variety.'

Braun (1981) recognised that it is difficult to know how to solve the problem of teacher commitment to computers in school and could only suggest financial incentives incurring a Government Solution. O'Shea and Self (1983) believe that artificial intelligence (AI) could prove to be the answer. As an alternative Hawkridge (1983) states

'education needs fundamentally new instructional paradigms.'

Self (1983) says that:

'Psychology has not produced the answers and if it does not, with little sign at present it must be concluded that we shall be unable to take full advantage of the new information technology in education.'

A major criticism of several noted education computer experts is the fact that most schemes put forward to stimulate the growth and use of computers, and CAL in education are short term initiatives by the Government with more of a political motive rather than educational.

All of these criticisms have some validity and hopefully the discussion in Chapter 7 in the final conclusion, will allay some of the fears they raise. These criticisms levelled at Educational Computing appear to paint a gloomy picture. However, two recent initiatives would appear to show a change in the right direction.

The most recent of the two was by the Department of Trade and Industry in February 1989, to inject four million pounds into L.E.A.'s for the provision of computing equipment and peripherals to use in Design and Technology courses in schools. The money can be spent in one of two ways. Up to half of it can be spent on part A, on 16 and 32 bit equipment only; alternatively all of it can be spent on part B.

Part A allows authorities to buy 16 or 32 bit computers and software to provide a complete package for:

Desktop Publishing

Computer Aided-Design (CAD)

Business i.e. word-processing, spreadsheets, databases and graphics.

Art and Design - any packages the teacher reasonably uses in design and technology courses.

The other half of the money can be spent on part B items; High quality printers i.e. laser or 24 pin dot matrix, Plotters, Scanners or digitizers, Control Technology packages and Software for Desktop Publishing, Art and Design, and Business Studies. As an alternative to the above approach all of the money can be spent on part B items. Lewis (1989) intimates that:

'Each authority must ensure that the equipment and systems purchased are used across the curriculum and age range (at least 20 per cent of the money must be spent on primary schools) and to ensure that pupils have become familiar with designing processes and have had experience of applying them to real life tasks.'

The DTI will expect a report after a year and provides the names of contacts at the five computer companies with a major interest in the education market - Acorn, Apple, Commodore, IBM and Research Machines. All five have appeared to have responded very quickly and have put together special packages.

The second of these is the development of the National Curriculum from 5 - 16 see DES (1985). All the National Curriculum Subject Working Groups are being asked to indicate the potential for using information technology (IT) and developing capability in its use in their particular areas. The Design and Technology Curriculum Working Group had been asked to recommend attainment targets and programmes of study which provide a framework for the development of IT capability across a range of subject areas.

DES (1989) in its Aims of IT in schools section makes the following statement:

> 'It has a critical role in enhancing the learning process at all levels across a broad range of activities including but going beyond the National Curriculum. Through the use of IT in the curriculum, schools will be helping pupils become knowledgeable about the nature of information, comfortable with the new technology and able to exploit its potential.'

This quote and the Aims of IT in schools and Objectives for IT 5-16 shown in Figures 1.1 and 1.2, Appendix 1 respectively indicate the efforts to produce a cross curricular approach to IT and its use as a 'tool' and for simulations.

Further to this the National Curriculum Council (1989) document emphasises as shown in Figure 1.3, Appendix 1 that IT capabilities should be developed cross curricular activities, with the emphasis on flexibility and pupils taking greater responsibility for their own learning. Clearly an indication towards a student-centred learning approach.

The two initiatives described previously would appear a step in the right direction towards producing compatibility of hardware amongst the various schools which could result in greater incentives to produce more acceptable software.

1.4 CAL in Further Education

A great deal has been written about Computer Assisted Learning within the schools environment. The above paragraphs have briefly outlined these developments and the resulting criticisms concerning the course these developments have taken. However, the parallel picture for CAL developments in the Further Education Sector, and in particular in the area of Electrical and Electronic Engineering is little reported and documented. However, there are certain schemes and initiatives which have had an affect. The CET organisation described previously has as its specification both coverage of schools and further education. A recent initiative with which it has been involved has been the Interactive Video in Industry and Further Education (IVIFE) incorporating material for Electronics, this is outlined in Chapter 5, Section 5.

Another body which has had a specific influence on further and higher education curriculum developments involving such as those in Information Technology including CAL is the Further Education Unit (FEU). This was set up in 1977 as the Further Education Curriculum Review and Development Unit, but renamed as FEU in 1983. Its remit is outlined in FEU (1988) as follows:

a) to review and evaluate the range of existing curricula and programmes.

b) to determine priorities and recommend improvements.

c) to carry out curriculum studies.

d) to disseminate FE curriculum information.

In terms of their actual commitment to Information Technology FEU has continued to support the permeation of IT into Further and Higher Education curricula. This includes the work of the Courseware Unit and initiatives in fifth generation computing.

The Courseware Unit was set up in 1985 when the Department of Education and Science designated FEU as a respository for items produced under the ESG courseware programme. The work of the Courseware Unit now extends beyond ESG. It has a database of over 400 items of ESG courseware in production or already completed. This data is updated termly. There is also a Courseware Newsletter, containing articles of general interest to those wishing to integrate IT into Further and Higher Education. The first printed directory of courseware was published in April 1987 and the growing collection of previews have been given to NERIS (The National Educational Resources Service). This means that previews can be searched on line through Prestel. Other valuable work of the unit see FEU (1987) has included the following projects RP(385 overseeing the production of a guide to authoring languages RP(407), involvement in the evaluation of the funding of the Manpower Services Commission Artificial Intelligence programme of education and training and RP(410) the evaluation of open learning materials.

Two other major projects which are of importance are now outlined. One the FEU (1983) The Computer Literacy document outlining the reasons for inclusion of some form of computer literacy in further education and the incorporation of IT into the curriculum. The authors of this document suggest that:

> 'it should include awareness of computer jargon, computer systems, the skills to perform useful tasks by means of a computer and some minimal experience in the writing of a computer program using either normal High level languages or author languages.'

The authors make reference to the use of CAL to assist in such programs.

The second of these is detailed in FEU (1985) which documents a study on Computer Based Learning in Further Education. A major aim of this study was to raise the staff awareness of the use, acquisition and evaluation of computer based learning materials. Also to encourage the generation of new ideas and initiatives in new courses and associated curriculum development.

Apart from the above initiatives outlined there have been major curriculum changes since the early sixties in further education. This is discussed in detail in Chapter 2. It has resulted in the formation of new BTEC (Business and Technician Education Council) Ordinary and Higher National Certificate/Diploma courses in Electrical and Electronic Engineering amongst others. This was a result of the Haslegrave report (1969). Along with the changes in Information Technology this has resulted in courses with a high Microelectronics/Microcomputing content. However, in the main the computers have been mainly associated with the specialist subject, such as microprocessor systems. This has usually entailed the use of single board microcomputers for assembly language programming. With some applications written for BBC and IBM compatibles by education equipment manufacturers for use of the computer as a controller.

Applications in the area of general purpose CAL have been either scantily reported or are non-existent. It is with this state of affairs in mind, the recent introduction of the Education Reform Act see DES (1988) and the National Council for Vocational Qualifications see NCVQ (1989) that an investigation into both the present and future use of Computer Assisted Learning in BTEC National and Higher National Certificate Courses in Electrical Engineering see DES (1969) would be an extremely useful exercise in the light of current changes taking place in the field of further education.

The subsequent chapters attempt to outline the resulting findings and the conclusions drawn from them.

CHAPTER 2

CURRICULUM

2.1 General

Changes in society, in political perspectives and in peoples views about what is permissible and what is not, are but three areas of change which affect views about what is taught in schools and colleges, and whether what is taught should be changed.

Conditions of the economy and technological changes also influence how people think about the content of education. Should it be, for example, more vocational and less academic, should there be a basic core of subjects and fewer choices, should work experience be compulsory and, in different direction, should every effort be made to preserve the teaching of the arts as a unique area of educational experience? At present both unemployment, an immediate concern, and the microprocessor, a fundamental technological change, are cited as justifications for a more vocationally oriented curriculum and for the compulsory teaching of computer studies and information technology.

Interest in the content of education, in the curriculum, is not, of course, simply a contemporary phenomenon. It has many historical counterparts. Over 2000 years ago Plato was interested in what the leaders of an ideal state should be taught, and many philosophers and statesmen since have pondered the educational problems of society. The reason for their interest is simple: the content of education, the curriculum, is at the heart of the educational enterprise. It is the means through which education is transacted. Without a curriculum, education has no vehicle, nothing through which to transmit its messages, to convey its meanings, to exemplify its values. The assumption has been made that the terms 'curriculum' and 'the content of education' mean one and the same thing. This is a valid assumption if by the content of education is meant the course of study to be followed in becoming educated. This is in fact the oldest known meaning of the word curriculum.

Perhaps a more fitting definition of curriculum for further education purposes is that of Vincent and Vincent (1985) who defines it as:-

> 'covering the purpose or general direction of an educational institution, and what is actually learned in the classroom by the students'.

Stenhouse (1975) calls these two views of curriculum the 'reality' and the 'intention'.

Whilst it appears difficult to form a consensus of opinion concerning the definition of curriculum, that of curriculum change is more clear cut. Curriculum change is a term used to cover both innovation (which implies a complete break from what has gone before) and development (which is a modification of what has gone before). It is appropriate therefore to consider innovation and development as part of a continuum with innovation at one end and development at the other.

What makes curriculum change of great importance in education is that it may denote bringing about changes in methods of teaching and learning as well as changes in the programmes and or courses. Such changes that have and are taking place in the further education sector at present make it important for us to look at the theories and models of curriculum and how subsequent changes may affect the use of computer assisted learning as a learning vehicle in the new stratagems of BTEC and the NCVQ.

2.2 Agents of Curriculum Change

Curriculum changes in further education are subject to the constraints of the particular organisation and to various outside agencies. Vincent and Vincent (1985) outline the following as agents who play a part in curriculum change in further education.

1. Department of Education and Science (DES); the local education authorities (LEA's); and the Manpower Services Commission (MSC) now renamed the Training Agency . These three are the main resource providers (the role of the MSC has grown in recent years with the increase in unemployment).

2. Her Majesty's Inspectorate (HMI's); LEA Advisers; regional advisory councils; schools; polytechnics; universities; the further education unit (FEU); the local consortia associated with the 'Mode 3' General Certificate of Education.

3. The curriculum validating agencies such as the Business and Technician Education Council (BEC and TEC), which amalgamated in 1983 to form BTEC; the City and Guilds of London Institute; the Council for National Academic Awards; the Central Council for Education and Training in Social Work; the National Nursery Examination Board; the Royal Society of Arts; the Union of Educational Institutions; the Institute of Management Services; the MSC; the industrial training boards. The members and officers of all these bodies must be included as part of further education curriculum change.

4. The employers; the industries.

5. The colleges, their administrative and teaching staff, and their students and prospective students.

6. Pressure groups.

A further four can be added to this list as they have and will have in the future an impact on further education curriculum.

1) TVEI - This was first introduced in 1983 as a pilot scheme, and was intended to enhance the quality of technical and vocational education for 14 to 18 year old students of all abilities. It marked the first direct intervention of the Manpower Services Commission (MSC) now called the Training Agency in schools provision and was unusual in that the contract was between MSC and LEA's. The extension of TVEI is unique as an educational initiative in that it has the aim of being accessible to all students in the 14-18 age range. It is planned that all such students should be engaged in TVEI extension by 1992.

The fundamental difference between pilot and extension is that the TVEI pilot programme was confined to a small number of pupils who in some cases took additional pre -vocational options and in others received 'enhanced' learning programs. For a variety of reasons the 'bolt on' option method has rarely been effective while enhancement, attempting to deliver TVEI objectives through the main program of study is difficult to achieve.

The TVEI extension was announced as a national programme in Working Together (HMSO 1986). It has developed from the initial concept of a set of work-related and/or technological options to being an agent for change across the whole curriculum. The intention is to provide a wider and richer curriculum supporting broad balanced education for all young people. TVEI is now as much about curriculum delivery as design, and emphasises learning processes in addition to subject content. TVEI developments are also being used by LEA's as part of school/college consortia management arrangement and for authority - wide strategic planning of provision.

The FEU (1989) see this common curriculum as more than a set of subjects or a course; in other words, it is more than the content of a learning programme. It should also be seen more as that which is experienced by learners, than that which is taught... involving all of those planned educational processes which facilitate, or if they go wrong inhibit learning.

2) CPVE - This is a national award set up in 1984 based on a framework within which a programme of approved learning and work related experiences may be constructed. It is offered jointly by BTEC and City and Guilds with an award on completion of such a programme. It is based around five core areas and five vocational areas. The normal length of the course was 1 year for post 16 year old students i.e. sixth formers and could be studied alongside 'A' levels. However from September 1989 following an evaluation of CPVE, it will now be a 2 year course. The new system provides the breadth and balance required to meet the needs of TVEI. Elliott (1989) implies that:-

'Recent independent studies by several LEA's have shown CPVE to most closely meet the concept of an Entitlement Curriculum for Post - 16 students. The emphasis throughout the course is on negotiated experiential learning'.

Strong tutorial support is essential with reviewing of achievements and the setting of new agreed targets. Certification being by a record of achievement which sets the achievements in context. Relevant work experience is an important course requirement. NCVQ & CPVE (1989) leaflet outlines the broad purpose of it as follows :-

'...CPVE provides opportunities to demonstrate the ability to learn to employers, college selectors, parents, and holders themselves. In this way students can demonstrate their potential for further vocational education and training. The programme also allows the students to make informed realistic choices about future employment training and qualifications'.

3) NCVQ - The National Council for Vocational Qualifications (NCVQ) was set up in October 1986 following the government initiated review of vocational qualifications in 1985 and the subsequent report of April 1986. It is an independent body set up with two key aims TUC (1988);

1) to establish a National Vocational Qualification (NVQ) framework which is comprehensible and comprehensive, and to facilitate access, progression and continued learning.

2) to improve vocational qualifications by basing them on the the standards of competence required in employment.

The role of colleges in the above scheme was clearly defined by the NCVQ. Since the new NVQ's will require the development of assessment methods which recognise competence as defined by industry, and the parallel development of complementary learning opportunities, the NCVQ see the colleges role as follows, (NCVQ Series 2 1986) :-

1) providing high quality learning opportunities through modular training, open learning packages, computer assisted learning, and experiential learning as well as through traditional courses.

2) providing consultancy and guidance services to help design and run effective training and assessment programmes.

3) staff development and training for those in industry and education.

The establishment of the NVQ framework and relational developments will create opportunities for colleges to provide a high quality and flexible training and certification service. Success in taking advantage of these opportunities will be gained by developing attitudes which reward enterprise and support new ways of working. This will involve making the right contacts with employers to clarify and define their needs, and ensuring that the assessment of trainee's competence is conducted rigorously. The challenge as seen by the NCVQ (1986) is :-

> 'is to establish not only a 'learning society' in which self-improvement is a natural process, but a qualified society in which individuals, employers and the community at large know and value what has been achieved through qualifications.'

Though the list is quite formidable it is by no means exhaustive; it does serve however to underline the scale of the problem.

What then of the strategies to bring about change; Hoyle (1969) indicates that a 'power coercive' strategy is:-

> '...the most common form of administrative intervention to secure change'.

However, Hoyle adds that there is a strong sentiment against using this kind of strategy in education because without the commitment of both the teachers and the students educational ends cannot be achieved. Taba (1962) argues that:-

> 'changing the curriculum means changing people and institutions'.

Power coercive strategies are one of three broad categories of planned organisational change identified by Chin (1968), the other two categories are 'normative - educative' and 'empirical - rational'. They can be summarised as follows :-

Power - coercive - These strategies are based upon the use of power to alter (by limiting alternatives directly influencing actions, and shaping the consequences of acts) the conditions under which other people act. This is the same as political conflict that invariably arises,as Kogan (1978) points out:-

'whenever education seeks to move forward'.

Nor,say Bennis, Benne and Chin (1969), is it:-

'...the use of power, in the sense of influence by one person upon another or by one group upon another, which distinguishes this family of strategies from those already discussed. Power is an ingredient of all human action'.

Power coercive or political administrative strategies emphasising political, legal, administrative and economic power as the main source of overall power. Per Dalin(1976) cites the use of guilt and shame, sentiment, and moral power as other coercive strategies.

Normative re-educative - These strategies derive from the social psychology of Kurt Lewin, and earlier John Dewey and Sigmund Freud. These strategies do not see the problem of innovation as a matter of supplying the appropriate technical information:-

> '...but rather a matter of changing attitudes, skills, values and relationships... Acknowledging the client's value system'.

The change agent has to learn to work collaboratively with the client in order to solve the client's problem. Bennis, Benne and Chin (1969) mention in relation to strategies of this kind, two groups of strategies:-

a) those which improve the problem solving capabilities of a system; and

b) those that release and foster growth in the persons who make up the systems to be changed.'

Per Dalin (1976) claims,emphasis has been placed on releasing creativity in persons, groups and organisations to cope with increasing social changes. These strategies do not believe, as do the third type of strategy, the empirical - rational, that creativity has to be imported from outside. However normative re-educative strategies recognise the importance of knowledge as a source of power. The flow of information going from those who know to those who do not know is a source of power. This is recognised by all of the strategies.

Empirical-rational - These strategies appeal to the intellect, by demonstrating the greater effectiveness of some new practice or idea over existing ones. Young (1970) has shown that the method involves linking innovative processes with research and development. Hoyle (1969) mentions that these strategies often utilise consultants to establish the link between knowledge and change. He also claims that while this has probably been the major approach to curriculum in the U.K. consultants have placed emphasis on content and have neglected change processes within the schools and colleges.

A profile of the position of change on a continuum incorporating the college, the course, the aspect of the course is a necessary starting point before contemplating strategies for curriculum change. Bolam (1976) argues that there are two major dimensions involved in change: (a) the process of innovation over time and (b) the system of change. He offers a conceptual framework, which has what he calls 'modest purposes', to his overview of the field. He takes each of the following four factors: the change agent; the innovation; the user system; and the process of innovation over time, and explores them in great detail.

Finally the limitations and strengths of the conceptual framework are considered in relation to an actual complex innovation. He considers the period during the 'innovation process' to be the most complicated as far as understanding the outcome of the innovation is concerned. At this stage the key questions are to do with the strategies, the modes of communication of the change agent, and the response of the user to them and the 'innovation'. His model is simple and operational and although he intimates it falls far short of its ultimate purpose, nevertheless it seems clear that all four factors are relevant to an understanding of the way in which changes do or do not take place.

2.3 Curriculum Theory and Design

2.3.1 Educational Ideologies

The ideological perspective is a useful one in helping characterise the nature of current discussion in education.

Taylor and Richards (1985) defines ideology as:-

> 'a system of beliefs and values held in common by members of a social group, each of whom draws on this system of meanings in explaining the world or part of it (e.g. education)'.

Ideologies contain both factual and evaluative ideas which are taken for granted within the ideology. Ideologies articulate members' views of reality (or part of it), present these in a more or less coherent form and compete with other ideologies for acceptance of their views by other people in a society.

Educational ideologies represent different clusters of beliefs, values, sentiments and understandings, but all purport to explain what education is and its relationship to society.

The interplay among ideologies in any education system influences greatly the way in which education is conceived by those who work in the system or by those who are its clients and consumers. On this view what counts as 'education' is ideological in character and varies with the struggles, negotiations and compromises among groups each with its own ideology.

Davies (1969) put forward a four fold classification of major educational ideologies.

Conservative - This stands for stability in the curriculum, emphasising a continuity with the past, interested in transmission of culture from one generation to the next. The learning process is towards teacher domination rather than child/student centred.

Revisionist - This ideology values modernisation, efficiency and the expansion of education to produce a skilled labour force. Educated manpower is regarded as one of the nation's greatest assets in international economic competition. An effective, updated curriculum is seen as an essential component of the nation's ability to compete. This ideology values scientific and technological studies and aims to make these available to any pupil/student provided he/she has the 'ability'. Such an ideology was a major thread in the 'Great Debate' of 1976-77, subsequent official publications and recent developments such as the Technical and Vocational Educational Initiative.

Romantic - This centres on the individual rather than the nation. It is very much a child centred approach with the emphasis on; 'play', creativity, 'discovery', and themes. An hierarchy of knowledge forms is not recognised, but a more subjective view of knowledge is held; with children constructors of their own reality. Its main philosophy is an advocation of teaching as a process of mutual exploration between near equals; it views childhood as valuable in its own right and children as seekers after their own meaning.

Democratic - This advocates such values as equality of opportunity, supporting change in education and the wider society in order to realise this. It stresses importance of creating a common culture and a genuine democracy in which all social classes can participate on equal terms. Concepts such as 'equality of educational opportunity', 'relevance', 'continuing education' and 'democratic participation'. It talks of 'opening doors' to knowledge, providing 'access' to the 'high culture' for all building on a common core of meanings. Common schools and a common curriculum feature prominently as part of its platform incorporating open learning. Teaching is seen as open to negotiation between teacher and pupil/student: knowledge is objective, but needs constant reinterpretation in contemporary terms. All pupils require access to these knowledge structures, though the importance of their everyday experience and common sense knowledge is also acknowledged.

Scrimshaw (1976) outlined an alternative typology. He distinguishes five major educational ideologies:-

Progressivism - This views education as a means of meeting individual needs and aspirations. It encapsulates creativity, discovery and experiential learning towards a student centred approach.

Instrumentalism - This ideology stresses the responsiveness of education to the requirements of the current socio-economic order. It was started by Jim Callaghan in his call for the 'the great debate' on education. The ideology bears a great closeness to the revisionism ideology of Davies.

Reconstructionism - This conceives of education as an important way of moving society in desired directions.

Classical Humanism - This is where education serves the function of transmitting the cultural heritage. It contains elements of conservatism, based on forms of knowledge and concepts.

Liberal Humanism - This acknowledges the importance of the intellectual disciplines for all pupils/students and seeks to help create a common culture and participatory democracy through the provision of common educational experience. The national curriculum and its initiators Kenneth Baker and the H.M.I.'s (H.M.I 1985) embody this ideology. It is a compromise between classical humanism, conservatism and revisionism.

Taylor and Richards (1985) see ideologies as

'encapsulating the views of different groups, each seeking to put its own particular view of education'.

At a particular time, one ideology may become dominant and impress its imprint on the pattern, organisation and curricula of the educational system or particular sectors of it. At other times there may be no one dominating ideology to provide an overall sense of what education is. There may only be competing definitions pulling the system in different directions.

At present in the United Kingdom the ideologies being applied to both school and further education appear to encapsulate a democratic revisonist stance.

2.3.2 Models of Curriculum Design

As one of their important concerns, the agents and agencies described in section 2.2 are charged with the task of helping to create new courses of study or new patterns of educational activity for pupils/students in schools and colleges. The design of such intended curricula involves numerous factors - ideological, technical, epistemological, psychological, to name but a few. Developing curricula in a systematic way, as opposed to an adhoc approach is still relatively new. As a result a number of curriculum design models have been developed to further this enterprise. There are several of these models in existence, however the following are five of the major ones:-

1) Objective Model

2) Situational Model

3) Naturalistic Model

4) Process Model

5) FEU Model

Of these the Objective, Situational and FEU model are the most applicable to the curriculum developments that have taken place in Further Education. They will be discussed in detail in subsequent sections.

2.3.2.1. Objective Model

This design model which owes its influence to behavioural psychology was resurrected from the original model initiated by Bobbit in 1918 and systematised into a coherent rationale by Tyler (1949).

The Tyler rationale as it has been called centres on four major stages as shown in Figure 2.1 Appendix 2. The first of these involves clarifying goals, i.e. what is is hoped the curriculum will achieve. He indicated that goals needed to state both the kind of behaviour to be developed in the pupil/student and the area of content in which the behaviour is to be applied. These closely formulated statements of intent are termed objectives which are prespecified. The learning experiences offered children/ students are selected at stage two. As a third stage these experiences are organised to reinforce one another and produce a cumulative effect. The final stage is that of evaluation which examines the extent to which the objectives are realised in practice, thereby indicating in what respects the curriculum is effective and in what respects it requires modification. It is termed a rationale planning model on the grounds that is is rational to specify the ends of an activity before engaging in it often referred to as a 'means-end' planning.

Educationalists such as Popham (1969) and Gronlund (1978) have concentrated on making the first stage as clear cut as possible in order to provide clear goals towards which pupils/students and teachers can work and in order to facilitate the measurement and evaluation of the results of the curriculum. Both of these concerns have led to an emphasis on behavioural objectives which specify in terms of observable behaviours what a pupil/student should be able to do, think or feel as a result of a course of instruction. For the purpose of assessing whether or not they have been achieved, such objectives have to be specific, measurable and unambiguous. Bloom (1956 and 1964) had carried out work on the taxonomy of educational objectives which has proved to be very influential. He postulated three domains of education objectives: the psychomotor domain emphasising muscle and motor skills, and manipulation in all kinds of activities such as speech, handwriting etc.; cognitive or intellectual domain placing the greatest emphasis on remembering, reasoning, concept formation and creative thinking; affective or emotional domain emphasising qualities expressed in attitudes, interests, values and emotional biases. Within the cognitive domain, six broad levels of understanding (each with sub divisions) are classified, ranging from objectives concerned with simple recall of specific facts to objectives involving the evaluation of complex theories and evidence. Objectives in the affective domain range from those concerned with attending to phenomena to those indicating commitment to a philosophy of life. Figure 2.2, Appendix 2 illustrates examples of these. The influence of Tyler and the 'rational planning model' has provided the framework for further modifications and elaborations. This influence is most clearly seen in a design model offered by Wheeler (1967). The model is shown in Figure 2.3, Appendix 2. It has five basic stages, the first of these being extremely complex as general aims embodying broad conceptions of education are analysed into ultimate goals, mediate goals, proximate goals and specific classroom objectives. These provide the direction required for the selection of learning experiences, the selection of content, the organisation and integration of learning experiences and content, and the final evaluation stage which enables the designer to determine the effectiveness of the curriculum and hence to make modifications to it next time round. In its stress on specific, measurable objectives at classroom level and its divorce of learning experiences and content, the model is very much in the Bloomian tradition. Kerr (1968) in his curriculum theory model follows a similar trend:-

> 'For the purposes of curriculum design and planning it is imperative that the objectives should be identified first as we cannot or should not decide 'what' or 'how' to teach in any situation until we know why we are doing it.'

A further model is shown in Figure 2.4, Appendix 2. This allows for some reappraisal and analyse of the system as it stands. Identification of the task you wish to do. Break it down, analyse to what levels of knowledge, attitudes or skills needed and the target population aimed at. Before starting the learning objectives i.e. in behaviourists terms of learning outcome one would need to assess the student. One can then select ways in which you achieve that performance i.e. selection of groups, pairs, or individuals. Motivation will apply to all boxes and attitudinal and attentional aspects should be added. Define Assessment of students diagnostic or evaluation, continuous or end of year, or by observation. This model places least emphasis on objectives compared to others.

The Coombe Lodge Working Paper (0940) outlines a model for course development. If we examine Wheelers 'model' and lump together areas 2 and 3 and omit area 1 then this would appear to be the basis of the above mentioned mode, see Figure 2.5, Appendix 2.

This model by a subtle change of words is used to develop a whole course or for a whole college or even the whole national curriculum for Further Education. It could also be used to develop a scheme of work or the design of a particular lesson or labwork using formative evaluation at the end.

2.3.2.2 Situational Model

This model unlike the objectives which has its roots in behavioural psychology and the process model in philosophy of education, is rooted in cultural analysis. Lawton (1983) argues that education is concerned with the transmission of the most important aspects of a society's culture to the next generation.

Skillbeck (1976) has devised a model which locates curriculum design and development within a cultural framework: and refers to it in the following manner:-

> 'it views such design as a means whereby teachers modify and transform pupil experience through providing insights into cultural values, interpretative frameworks and symbolic systems'.

The model underlines the value laden nature of the design process and its inevitable political character as different pressure groups and ideological interests seek to influence the process of cultural transmission. Instead of making recommendations in vacuo, it makes specific provision for different planning contexts by including as one of its most crucial features a critical appraisal of the school/ college situation. The model is based on the assumption that the focus for curriculum development must be the individual school/college and its teachers/lecturers i.e. that the school/college based curriculum development is the most effective way of promoting genuine change at school/ college level. The model is made up of five major components see Figure 2.6, Appendix 2.

1. Situational analysis - This involves a review of the situation and an analysis of the interacting elements constituting it. External factors to be considered are broad social changes including ideological shifts, parental and community expectations, the changing nature of subject disciplines and the potential contribution of teacher support systems such as colleges and universities. Internal?factors include pupils and their attributes, teachers and their knowledge skills, interests, etc, school ethos and political structure materials, resources and felt problems.

2. Goal formulation - Statement of goals embraces teacher/lecturer and pupil/student actions (though not necessarily expressed in behavioural terms). Such goals derive from the situational analysis only in the sense that they represent decisions to modify that situation in certain respects.

3. Programme building - comprises of the selection of subject matter from learning, the sequencing of teaching - learning episodes, the deployment of staff and the choice of appropriate supplementary materials and media.

4. Interpretation and implementation - This is where practical problems involved in the introduction of a modified curriculum are anticipated and then, hopefully overcome as the installation proceeds.

5. Monitoring, assessment, feedback and reconstruction - This involves a much wider concept of evaluation than determining to what extent a curriculum meets its objectives. Tasks include providing on-going assessment of progress in the light of classroom experience, assessing a wide range of outcomes (including pupil attitudes and the impact on the school/college organisation as a whole), and keeping adequate records based on responses from a variety of participants (not just pupils/students).

The model is not an alternative to the objective or process it is a more comprehensive framework which can encompass either the process model or the objective model depending on which aspects of the curriculum, are being designed. It is flexible, adaptable and open to interpretation in the light of changing circumstances. It does not presuppose a linear progression through its components: teachers/lecturers can begin at any stage and activities can develop concurrently.

Taylor and Richards (1985) see that the model outlined does not presuppose a means - end analysis at all; it simply encourages teams or groups of curriculum developers to take into account different elements and aspects of the curriculum - development process, to see the process as an organic whole, and to work in a moderately systematic way.

2.3.2.3 F.E.U. Model

The F.E.U. has used an established model of the processes of curriculum development of which a version forms Figure 2.7, Appendix 2. The F.E.U. (1986) identifies the four stages as:

1. Analysis of the situation in which curriculum is required: of needs, and available resources.

2. Design of the curriculum to meet these needs: the identification of intentions.

3. Implementation and Interpretation of the design: the outcomes.

4. Evaluation: monitoring and feedback as to whether the needs are set, and the design and implementation are appropriate. These four areas are backed up by the support systems necessary for effective curriculum development.

Clearly this model has likeness to the Tyler/Wheeler objectives model and Skillbeck's situational model since it incorporates many of the general features of these two models. In fact the model can be seen as a generalised version of the approach to curriculum development within the further education sector. Its importance in the future of further education will be discussed in a latter section.

2.4 Developments in Further Education Curriculum concerned with Technician Education in Electrical and Electronic Engineering

2.4.1 State of Technician Courses Prior to Haslegrave

Prior to 1961 there was little or no technician education. There existed only craft type courses run by the City and Guilds and (National Certificate Courses (i.e. O.N.C. and H.N.C.). The subsequent decade saw a great growth in the number and range of technician courses offered by the City and Guilds of London Institute and of the number of students following them. This was largely the result of the White Paper (1961) "Better Opportunities for Technical Education", which identified a national shortage of technicians, resulting in part from the confusion of objectives in National Certificate Course (O.N.C., H.N.C. and endorsements), designed to cater simultaneously for technicians and would be technologists. Such courses have a very high wastage and failure rate. The development of C.G.L.I. courses tailor made for the intending technician only and with a consequent high pass rate had kept in education many who would have been lost. In 1961 there were only two such courses, which by 1970 had mushroomed to over ninety. Figures 2.8 and 2.9, Appendix 2 show the basic pattern of courses following the 1961 White Paper Better Opportunities in Technical Education. To outline the success of these courses in terms of reduction in wastage and greater examination success figures are given in Table 2.1, Appendix 2.

From the above data the structure of the courses appeared to be satisfactory. However, the Haslegrave Committee set up by the National Advisory Council on Education for Industry and Commerce (NACEIC) in September 1967 to review the provision for courses suitable for technicians at all levels (including corresponding grades in non-technical organisations) indicating that there were clear weaknesses in the pattern of technician education courses.

There are regional examining bodies that organise examinations and make awards and there exist particular relationships between the three types of examining and awarding bodies (National Certificate Committees, City and Guilds and Regional Examining Bodies). In all there were 27 Separate National Certificate and Diploma Committees and a very large number of committees concerned with technician work serving the City and Guilds and the regional examining bodies. Thus there did not exist any single body that was able to probe into the future and decide what the essential requirements were, i.e. there was a lack of co-ordinated effort. Bell (1972) stated that:-

> 'the general effect of the above set up was to present a bewildering picture of complexity to employers, students, and even those concerned with the administration had difficulties in following all of its ramifications.'

Also many of the syllabuses of National Certificate and Diploma course have been biased towards the requirements of professional bodies and few courses other than some City and Guilds Courses, had been designed solely for technicians. Changing the pattern of courses and in syllabuses had to be made to meet industries changing pattern, and there was not sufficient opportunity to base the syllabuses on the needs of industry in the region. The distinctions in titles - National Diplomas and Certificate and City and Guilds Certificates led to discriminations based on type of study instead of total content of study covered and the depth of such study. Such discriminations influence unfairly the subsequent careers of students. It was not possible for a student to transfer from one course to another that is suited to his/her abilities and desires very easily. There was no clearly defined access for a craft student to transfer to proceed to professional status. Report of the Committee on Technician Courses and Examination (1969) stated that:-

> 'due to the separate development of National Certificate Diploma and C.G.L.I. Technician courses and the inclusion of new courses without thought of their effect on coguate provision, the integration of further education and industrial training could be planned on an adhoc basis only, course by course. Also business education despite the growth of the O.N.C. in business studies lacked a coherent pattern of courses at the technician equivalent level'.

These weaknesses of the pattern of technician courses set up in 1961 can best be summed by Cantor and Roberts (1972), in the following terms:-

> 'The main weakness of the present system is perhaps that it has tried to fulfil two different purposes by providing education both for the technologist and the technicians.'

With the rising standards of entry, increased provision of full-time courses and the growing complexity of industrial techniques, the gap between technician and technologist has grown and the part-time route to technological qualifications has become increasingly inappropriate.

It would appear that these older type courses above, particularly the National Certificate Courses follow very much some of the education ideology outlined by Davies (1969) earlier in the text in the conservative notion which values stability and continuum with the past, an elitism approach to preserve the status quo and extend it. It employs concepts such as standards and high culture using metaphors such as structures', 'inherited', and 'apprenticeship'. An involvement with structure of knowledge and the concept of 'objective knowledge' to which students have to accommodate. There was also a leaning towards a subject-centred curriculum with the learning process geared towards teacher domination rather than student-centred. In the case of the above courses they were centred around Mathematics, Electrical Principles, Communication Studies and Specialist subjects. Hence their firm alliance to structure and heavily teacher -centred (chalk and talk syndrome), plus a high degree of subjectivity in their content. The National Certificate course had an elitist approach in terms of centring towards technologists and professional qualifications, students being "fodder" on the way if they did not achieve the standards set.

Scrimshaw (1983) alternative typology, in particular the ideology of classical humanism encompass conservatism applicable to the afore mentioned curriculum based on forms of knowledge et al P.H. Hirst (1965) and R.S. Peters (1965). However, the inclusion of the technicians based courses following the 1961 White Paper, "Better Opportunities in Education ", would incorporate the above plethora of courses into some of the ideals of liberal humanism and revisonist ideologies.

It was with all the above reasons that the Haslegrave Report (1969) recommended a new pattern of courses leading to Higher Technician Diplomas and Certificates preceded by comparable qualifications obtainable at the ordinary level, thereby restricting the new system to technician education. The following section examines the pattern of courses recommended by the Haslegrave Committee.

2.4.2 New Pattern of Technician Courses in Electrical/Electronic Engineering

The unified pattern of courses are shown in Figure 2.10, Appendix 2 in diagrammatic form. These have been based on modular or block principle. The contents of the course were designed to give students a sound basis of mathematics, science and technology with a knowledge of technology and techniques appropriate to the jobs that they are carrying out at the periods of their studies. In the latter stage students are given knowledge of technology and techniques for future jobs in their particular branches of work. Provision is also made for refresher and re-training courses in which will be given knowledge of technology and techniques needed for fresh jobs.

There are four awards based on performances and attainments in studies, Technician Certificate, Technician Diploma, Higher Technician Certificate and Diploma. In 1983 after the merger of the T.E.C. and B.E.C., B.T.E.C. National Certificate/Diploma and B.T.E.C. Higher National Certificate/Diploma, endorsements to certificates and diplomas can be obtained. The first stage, see Figure 2.10 Appendix 2, leading to the award of a Technician Certificate or Technician Diploma, extends over two academic years or approximately 600 hours for certificate and 1200 hours for the Diploma including a diagnostic period. The certificate course can extend for three years if no exemptions are given for 'O' levels spanning 900 hours. On the other hand, the Diploma course will span 1800-2200 hours for a two year full-time course. The certificate course is geared to the more practical approach, whereas the diploma course includes further study in both depth and breadth.

At Stage two further studies in Maths, Science, and technologies will continue. The Higher Certificate course spans two years of day release totalling 600 hours of study, whereas the Higher Diploma is usually two years full-time of 1200-1500 hours study. Some of the modules covered will be in depth, other studies will be breadth. Depending on the number of modules taken will depend the award of a H.T.C. or H.T.D. Finally at the third stage specialist courses are offered i.e. post Higher Technician awards. There is a great deal of flexibility in selecting the various modules. Figure 2.11, Appendix 2 illustrates the alternative routes for transfer from craft courses and students continuing in full-time education after the age of 16. Figure 2.12, Appendix 2 shows the schemes of further education in electrical and electronic engineering and in particular their relationship to the Technician courses.

All T.E.C. programmes are based on units and a credit system. A programme is defined as a scheme of study leading to an award of the T.E.C. and will have a title which is related to an occupational activity. A unit is a self contained and significant component of a programmed which will be separately assessed and if successfully completed, counts for credit towards an award.

Any combination of units leading to the award of a certificate comprises 15 units which together form a coherent programme of study normally completed in three years of part-time attendance or two years full-time attendance. Figure 2.13, Appendix 2 outlines the programme structures. After three years it was evident courses needed to be updated to incorporate more microelectronics as indicated in Figure 2.14, Appendix 2.

The Higher National Certificate Programmes comprise 10 units completed after two years, Figure 2.15, Appendix 2 illustrates the original programmes allied to the certificate programmes of Figure 2.13, Appendix 2. Figure 2.16, Appendix 2 outlines the updated programmes to take into account the developments in microelectronics.

The Higher National Diploma courses are not outlined since in general they are not carried out a further education colleges.

In order to administer the scheme the Technician Education Council was set up in March 1973 to fulfil the recommendations of the Haslegrave Report. Its main function was to rationalise existing provision, and to develop a system of technical education which is responsive to both industrial requirements and students needs and yet can be operated economically and efficiently. In October 1983 the Technician Education Council and Business Education Council merged to form one coherent body to cover both the Technical and Business sectors of education hence the foundation of the 'B.T.E.C. organisation'.

T.E.C. policy had given particular emphasis to the specification of aims and objectives and assessment methods as key elements of curriculum design FEU (1981) 'T.E.C. policy on objectives - the T.E.C. policy statement (4.3.4) stated that:-

'the programme committees providing materials for the use of colleges will decide whether to issue draft syllabuses or to provide guidelines in a different form, for example, as a statement of learning objectives.'

In a circular, T.E.C. (1975), the council declared its aim to be:-

'that in due course all units should be written in the form of general and specific earning objectives.'

The style of objectives advocated and adopted in T.E.C. standard units was the subject of a T.E.C. Guidance note. T.E.C. (1976). In these notes an educational objective is defined as:-

'a precise statement of intent, describing some proposed changes in a learner. Anybody reading a list of objectives should be able to decide what behaviour the performance of a student should be on completing the list of objectives.'

A distinction is made between general objectives and specific objects. General objectives are used to give the general teaching goals, the major purpose of a unit and the specific objectives the measure by which it can be determined whether the general objectives have been attained. The specific objectives should be sufficiently clear and precise that little if any ambiguity exists in both the description and assessment. The general objectives are not in themselves specific enough to give an adequate description or avoid ambiguity in interpretation for assessment. Clearly from these policy statements the T.E.C. policy statements, the T.E.C. curriculum development is heavily based on the 'objectives model' which has its influence based in behavioural psychology.

It is clear that in the conception of the T.E.C. curriculum development, the model used was very much along the lines of the original Tyler and Wheelers' modified model.

The model programmes issued by T.E.C. programme Committees and the standard units follow the Bloom style of behavioural objectives and domains in that each has a set of Aim Statements. Each unit states both GENERAL AND SPECIFIC OBJECTIVES and has an associated analytical assessment specification. Appendices1 and 2 in Appendix 2 illustrates examples of standard units.

FEU (1981) - stated that the programme and unit Aims are the most generalised statements of educational intent, concerned with ultimate outcomes. The GENERAL OBJECTIVES express more precise intentions for a component of a unit. For each general objective a number of SPECIFIC OBJECTIVES are to be written in behavioural terms in such a way that it should be clear what the student of the objective will be able to do on completion of the necessary learning. The objectives should have certain components:

a. a verb indicating the LEARNING PERFORMANCE required e.g. defines;

b. An OBJECT the thing that has to be learnt e.g. stress;

c. CONSTRAINTS, within which the objective is to be realised.

In this example 'the constraint is that the definition is only to be as force/area.'

The main arguments advanced by TEC for basing curriculum design on a specification of general and specific learning objectives are that their use should greatly enhance the understanding of the curriculum by employers, teachers, and students and also provide a basis which allows standards to be determined and monitored by the Council through its validating committees and moderators. Essentially these perceived advantages are concerned with ensuring clear communication between curriculum providers and users.

Advantages which other protagonists of behavioural objectives have claimed include the FEU (1981) claim that:-

> 'objectives enable rational planning and curricula, encourage thinking, make otherwise concealed values explicit and provide a basis for individual learning programmes.'

Other possible advantages are that the "objective" model provides a normalisation towards a standard of performance of students, and uniformity of content. Evaluation of the teaching/learning process gives a measurable target for the teacher/lecturer to aim at and also the student if he/she is told. By careful selection of objectives which all students can achieve then it rewards and encourages the achieving student. They can be matched to ability and attitude of the student and cater for the way in which learning takes place either slowly, linearly, impulsion, globally, top down or bottom up.

The task in front of the teacher/student is limited and ambiguity is removed i.e. outcomes of learning clearly specified. Ausubel the cognitive psychologist believes they provide a conceptual scaffold or advance organiser in building up cognitives which is useful if you had some vision of where you were going. Encouragement is given to the measurement of a wide variety of skills and in determining the validity of assessment. Memory learning is encouraged as developed by Bloom and implies the mastering of a specific objective before commencement to the next given stage or level.

It would appear to encourage the child/student centred learning approach rather than teacher centred and may help to measure standards, but at what cost?

Although the advantages of the objective model are reasonably valid there are a number of equally valid criticisms which can be made against it and impose limitations on the model.

These include the FEU (1981) statement that:-

'objectives do not adequately represent the structure of knowledge, are inherently ambiguous, with insoluble levels of specificity.'

Outcomes of education such as understanding, appreciation and knowledge cannot be fully translated into clear-cut observable behaviours capable of measurement. Taylor and Richards (1985) specify that :-

'only low level mental operations such as the recall of specific facts or the performance of certain physical skills can be unambiguously specified beforehand.'

From the subject units shown in Appendices 1 and 2, Appendix 2 it is clear that TEC feel the Affective domain cannot be measured and that Invention incorporates the skills of analysis, synthesis and evaluation, this indicates the difficulty of splitting knowledge into measurable categories. Some lecturers found the term Invention difficult to use in analysing objectives. This is clearly shown in the two units in Appendices 1 and 2, Appendix 2 where these skills will be under-emphasised in the design, and consequently the implementation of units. The separation of motor skills from the cognitive skills has undoubtedly led to some uncertainty about the categorisation of particular objectives. The danger that areas which combine intellectual and manipulative skills such as laboratory work and workshop activities will be under emphasised is evident in the relatively few objectives written and defined in the category Motor skills. This along with rather full unit contents led in the short term to a reduction in these types of activities and student-centred learning. Also the objectives model tends to lead the teacher/lecturer to teach purely to the objectives, giving a tunnel vision view of knowledge and the curriculum, and at the same time encourages students to learn a topic once and then forget it. If the objectives are not set at the right level then high achievers can be bored if too low a level and low achievers can fall by the wayside if geared at too high a level so falling back into the problems of pre Haslegrave. There is a tendency to encourage temporary achievement without testing repetitive or predicative achievement. The assessment pattern normally consisting of 3 phase tests (very often objective based) a final exam and assignment work tended to use up an unnecessary amount of actual learning activity time.

The objective model is criticised by Atkin (1975) as encouraging "trivia" a trivial content will produce trivial testing and also trivial skills. To produce more high level objectives is time consuming and lecturers find it difficult to devise such objectives, to design curricula incorporating them and to teach with them in mind. There are problems with the tendency to over-concentrate on low level objectives (which can be specified) to the neglect of more elusive education outcomes which cannot be so closely delineated. Also it is not at all clear how closely objectives have to be specified in different planning situations or how they can be adequately measured using present instruments. There are difficulties too when lecturers work together in planning or executing courses since there are often differences in values and interpretations underlying superficial agreement on objectives.

The objective model tends to restrict the lecturer and reduce his flexibility due to the objectives approach. This was very apparent with TEC since lecturers were tied to completing all the objectives with students to satisfy TEC committees and moderators. The vast plethora of paper work that it generated for teaching staff as much as any of the criticisms put forward tended to devalue the more positive aspects of the "TEC" model.

The objective model of curriculum development on which the initial TEC courses were developed provided a more solid framework of study having closer links to the students work than ever before and offered a more standardised performance measure than before. However, the very real problem of specifying knowledge in terms of behavioural objectives has led to units being produced which are not wholly adequate. Also units differ from college to college meaning that it was difficult to fully relate one course of study from one college with another unlike the old national certificate course.

Although there are strong criticisms against the model which can be summarised by Sockett (1976) which argues that

> 'pre-specification violate the nature of science which rests on the assumption that everything is in principle falsifiable. As a consequence all scientific knowledge is 'provisional' in character, and not absolutely and certainly true. Pre-specification pre-supposes that the results of scientific enquiry can be predicted with certainty, which runs counter to this basic principle and thus gives pupils/students a false view of the activity.'

Hirst (1975) who agrees with many of the criticisms levelled at behavioural objective models argues that objectives in curriculum design do not have to be expressed in behavioural terms. Ends have to be clarified prior to determinations of means. Such ends or objectives are very varied they include concept forms of perception and judgement, patterns of aesthetic response and attitudes, which are not behaviour at all. Such ends can be specified by enormously varied ways, some specific, some general, some behavioural, some not.

Perhaps the major criticism of the early TEC programmes and use of the objective model was that put forward by the FEU report (1981):-

> '..the way in which TEC has used and validated objectives and assessment plans has put too much accent on what the student learns rather than how they learn.'

The point was emphasised in the empirical-rational category of planned organisation curriculum change.

Also TEC was heavily criticised for the lack of a pilot study as Jack Mansell states in FEU report (1981):-

> '...This study is, in many respects, eight years too late ... if blame must be apportioned, it belongs to all those in education who acquiesce to untried curricular experiments.'

However, while some might say that they did not believe they had any real choice, others might argue that neither BEC nor TEC would have got off the ground if it had not been introduced fairly quickly using power coercive strategies. These were not seen as direct threats, but appeals made to 'social needs' and 'moral implications' and stress laid on social and technological changes and the idea that further education must adapt or go under. Possibly power coercive strategies were felt to be necessary at the administrative level. The evaluation report on TEC implies that the rationale for administrative re-organisation was to cope with areas of discontent in the curricula of technicians.

Russell (1981) makes a similar observation in his report Curriculum Control which examines the relationship between the central curriculum bodies and the colleges of further education (advanced (AFE) as well as non-advanced (NAFE) levels. Change it could be argued is usually brought about for administrative rather than learning and teaching reasons; however, it would be foolish to deny that some changes have also been brought about in the learning/teaching areas. The rationalisation, that was needed in the 1960's led to the Haslegrave report and the subsequent setting up of TEC and BEC is a major initiative to point to. This is now discussed in the next section in detail.

2.4.3. <u>The Changing of BTEC Programmes in Electrical/Electronic Engineering</u>

The BTEC council have realised that problems associated with the objective model. In its document (1986) "Policies and Priorities into the 1990's" BTEC made clear its commitment to promoting learning strategies that encourage students to:-

1) develop skills and personal qualities of general importance and application ability to working life;

2) experience their programme of study as a coherent whole, in which all the parts are well related to each other.

3) develop an enhanced capacity to cope with the demands and responsibilities of adult life and work.

4) apply their knowledge, understanding and skills.

They see assignments as an effective way of doing this; they have the special advantage of helping students to integrate their studies and to apply them to work related problems.

The trend of the units new programmes is away from the behavioural approach to objectives. It now deals in principle objectives and indicitive content with the teaching and learning strategies geared towards "hands-on" student centred learning, this being clearly stated in the units. Assessment is via in-course assignments embody in principal rather than specific objectives plus a final examination. However, some units are covered by 100% assignment work. The use of integrated assignments enables subject boundaries to be cross and other skills to be taken into account. With the emphasis on Common Skills and Core Themes as outlines in BTEC Documents (July 1986) and (October 1986). The above highlights a major failing of the objective model in that it was very much a case of teaching, units in isolation, and in an absolute structured linear fashion. The new model which adheres more towards Skillbeck's situational model shown in figure 2.6 and the general model put forward by the FEU in figure 2.7. This is emphasised by the greater interrelationship between units and more feedback at all stages of the teaching/learning strategy. Appendices 3 and 4, Appendix 2 illustrates the typical layout of the scheme of units, and Appendices 5 and 6, Appendix 2 typical units.

Support for the situational type of model comes from Sockett (1976) who advocates a process of 'curriculum design through structure;'. He believes that curriculum design and development have to be slow, piecemeal and uncertain, since there are a multitude of interacting factors involved and since the activities of those party to the enterprise are largely habitual. Curriculum design involves understanding the structure of the curriculum as it presently exists.

Certainly these new developments are an improvement on previous BTEC philosophy. The actual units are better prepared and as a result will receive wider acceptance making for a greater degree of standardisation nationally. Although, the new scheme has only been in force since 1986 with the National Certificate/Diploma programmes and 1989 with the Higher National Certificate/Diploma programmes, effects have already been apparent.

The electronics team of which I am a member at the college has already decided to change its teaching approach to a student-centred one. This has already had quite an impact. Students receive a consistent approach in presentation of the units. They have become more motivated and self reliant with the responsibility on them for their own learning. The staff now have a greater flexibility than before and in their notes as facilitators of the learning process can stand back and assess students progress in a more constructive way than before. Generally there is a better teacher student relationship with continuous feedback of information between teacher and student. The next couple of years should give us a good overview of how well or otherwise the new BTEC programmes are fulfilling their purpose.

It would be worth pointing out at this stage that a lot of the philosophy behind the new BTEC unit in Electrical/Electronic Engineering owe their influence to the FEU paper (1984) on the design of microelectronics programmes which recommends an overall approach to the design of the microelectronics curriculum The major impetus for the introduction of microelectronics into the FE and HE was via the Alvey Committee (1982) whose main criteria was to encourage the development of information technology to produce a workforce skill in the new technologies.

We should not dismiss the objectives model out of hand in terms of its use in BTEC. Its original concept was good, it gave structure to previously unstructured course material and provided the means for a wider audience of students to participate and achieve success. Its reduction in the wastage of students alone means that it achieved a great deal./ A base was laid from which hopefully we appear to have a more meaningful student-centred curriculum in electrical/electronic engineering which will enable the students of the late 80's and the 90's to be free thinking problem solving engineer's needed for the 21st century.

Stenhouse (1985) probably best sums up this critique:-

> 'The objectives model is appropriate for both training and instruction, but breaks down when it comes to inducting pupils/students into knowledge. The latter involves getting pupils/students on the 'inside' of knowledge forms inducing them to think creatively and to make considered judgements. It is not something to think with; Education as induction into knowledge is successful to the extent that it makes the behavioural outcomes of the students unpredictable. Improvements in education comes not from teachers, being more precise about objectives, but from their analysing and criticising their own practice.'

There is much good advice here which teachers and lecturers should well heed, and take note of if the curriculum is to progress successfully.

2.5 Curriculum and its Relevance to Computer Assisted Learning

The ideologies, models and agents of curriculum change through which the present BTEC curriculum in it present form evolved has created a vibrant climate for Computer Assisted Learning, with its emphasis on student-centred learning and the use of a wide range of resources.

On the other hand, drawbacks relating to the fact that the use of new technology in the classroom can cut into previously established patterns of the curriculum, as well as classroom organisation, teacher's strategy and style. Computer Assisted Learning material is bound, therefore, to be seen in some sense as a disruptive influence in the curriculum. Skillbeck (1975) distinguishes between curriculum change that may be planned by the participants who wish to change the situation for their own satisfaction, and change which is haphazard, which the participants may choose to accept or reject. He also draws a further distinction between change that builds upon the established system through the absorption and assimilation of new elements and change which by being more disruptive and comprehensive provides genuine innovation.

Innovations that incorporate new technology tread a wary path between existing practice while attempting to explore the potential of the new.

In the main computers in curriculum should work through a practical approach focused on the curriculum and its concerns. The computer should be used to assist both the learner and the teacher/lecturer in their tasks within the whole curriculum. It is with this in mind that the present state of CAL in BTEC National/Higher National was to be investigated.

CHAPTER 3

LEARNING

Human activity we call education is largely based in our society on the related processes known as 'teaching' and 'learning'. The formalisation of these processes, so that they are carried out within schools, colleges and institutions, results basically from society's conscious responses to fundamental problems of adaption and survival. Curzon (1985) states:-

> 'Education is our society is generally concerned with the handing on of beliefs and moral standards, knowledge and skills. It may be viewed as 'the nurture of the human personality' and as 'investment in human capital'. In its essence it is a recognition of the fact that society's mode of life must be learned - since an understanding of it is not inherited - by each individual. Learning depends on the individuals experiences within, for example his family, his social environment and more specifically, the educational institutions he attends.'

A major problem with learning theories is establishing a definition of learning. Dictionary definitions provide a useful guide. The Short Oxford English Dictionary states:-

'To get knowledge of (a subject) or skill in an art etc. by study, experience, or teaching. Also to commit to memory ...'

Cassell's New English Dictionary defines it as:-

'To acquire knowledge of or skill by study, experience or instruction.'

More specific definitions have come from the philosophers and psychologists. Gagne(1983) refers to it as:

'A change in human disposition or capability which persists over a period of time, and which is not simply ascribable to the process of growth'.

Kimble (1963) defines it as:-

'A relatively permanent change in a behavioural polentinity which occurs as the result of continuous reinforced practice.'

Smith (1966) on the other hand implies that it is:-

'A process of reorganisation of sensory feedback patterning which shifts the learner's level of control over his own behaviour in relation to the objects and events of the environment.'

Hilgard and Bower (1981) see learning as:-

'The process by which an activity originates or is changed through reacting to an encountered situation, provided that the characteristics of the change in activity cannot be explained on the basis of native response tendency maturation or temporary states of the organism (e.g. fatigue, drugs etc.).'

Ryle (1983) sees it as:-

'Learning is becoming capable of doing some correct or suitable thing in any situations of certain general sorts. It is becoming prepared for variable calls with certain ranges.'

Finally Galperin (1965) defines learning as:-

'Any activities that develop new knowledge and abilities in the individual who carries them out, or else cause old knowledge and abilities to acquire new qualities.'

These are but a few of the more modern definitions of learning all of which have their merit. However, the following are definitions of learning and teaching respectively which give a general overview of each.

Curzon (1985) states:-

> 'learning can be considered as the apparent modification of a persons behaviour through his activities and experiences, so that his knowledge skills and attitudes, including modes of adjustment, towards his environment are changed more or less permanently. By extension, teaching can be considered as 'a system of activities intended to induce learning, comprising the deliberate and systematic creation and control of those conditions in which learning does occur.'

Clearly it is a complex issue what learning is and psychologists over the years have been attempting via their experimentation and subsequent theories to define it and explain how we actually learn. This has resulted in a number of different schools of thought with this field.

3.1Theories of Learning

3.1.1 Behavioural Theory

Behaviourism is based on a concept of psychology which sees its essence in the examination and analysis of that which is 'publicly observable and measurable.' It looks at the relations between an organisms responses (i.e. measurable muscle movements) and stimuli (changes in the physical energy of some aspects of the organisms environment). In relation to teaching, behaviourists place emphasis on the teacher's task to provide for and to promote the adhesion of desired responses to appropriate stimuli. Pavlov, Watson, Thorndike and Guthrie are representatives of the behaviourist school.

Pavlov (1849 - 1936) A major work of his was Conditioned Reflexes (1927), which has been the basis of much study in recent years on the importance of conditioning in the process of learning. He saw learning as being inseparable from 'association'; hence what teachers do, how they do it, in what surrounding circumstances, to what ends become significant for the study of instruction. Human personality is determined, according to Pavlov, by environment, biological inheritance and conditions of upbringing and as person's general behaviour depends largely on his 'acquisitions', i.e. the habits he has formed. The part that can be played by a teacher in the process of habit formation will be obvious. Formal education, strengthened by other experiences, can exert a decisive influence on that process.

Watson (1878 - 1958) His early work as a researcher into animal behaviour led him to examine psychology in strict behavioural terms. He postulated that human beings are born with some few reflexes and emotional reactions (such as love, rage, fear), but no instinct (which are merely stimulus response (S R) links); all other behaviour is the result of building new S R connections. Learning, however, produces no new connections in the brain they exist already, as part of the learner's genetic constitution. Hence, our behaviour, personalities and emotional dispositions are learned behaviours. The human being as a consequence is no more than the sum of experiences. Conditioning was seen as fundamental to learning. The conditioning of the learner, through his environment and experiences, in which the teacher may actively intervene, will determine his acquired patterns of behaviour. Heredity and instincts counted for little as contributing to human behaviour, learning was the all important factor.

Thorndike (1874 - 1949) His main interest was animal psychology and, in particular intelligence and learning. The basis of Thorndike's approach to problems of behaviour lay in his belief that human behaviour could be analysed and studied in terms of stimulus response units. The essence of behaviour was to be found in the initiation of events and an individuals reactions to them.

Thorndike's contribution to the theory of learning may be summarised by a statement of his major 'law' The law of effect was formulated as follows: an act which results in an animal's experiencing satisfaction in a given situation will generally become associated with that situation, so that when it recurs the act will also be likely to recur. An act which results in discomfort tends to be dissociated from the situation, so that when the situation recurs the act will be less likely to recur.

Thorndike's work with its emphasis on the significance of the S R bond reminds the teacher of the importance of viewing all his activities (intended and otherwise) as contributions to the learning process.

Guthrie (1886 - 1959) He produced the definitive work 'The Psychology of Learning' (1935). His theory of learning is based on one general principle that of simultaneous contiguous conditioning. He argues that if someone does something in a given situation, the next time they are in that situation they will do the same thing again. Rewards and punishments he says are of little significance and are in themselves, neither good nor bad. Whether they are effective or ineffective will be determined by what they cause the learner to do. What is really vital in the learning situation is the control of stimuli so that desired responses may be elicited. 'What a person does is what a person will learn.'

3.1.2 Purposive and Neo behaviourists

The early behaviourist doctrines have been extended and modified by psychologists such as Tolman, Skinner and Gagne. Tolman's views are noted in what is termed 'purposive behaviourism.' Skinner brought scientific precision to the detailed study of the learning process viewed in strict behavioural terms and created a theory based on 'operant reinforcement.' Gagne investigated the instructional technology needed for competency based education and developed a psychology based upon behaviourism, related to the observable circumstances that are obtained when acts of learning occur. Each of these psychologists had made a deep impact on the principles and practice of teaching in schools and colleges.

Tolman (1886 - 1959) He is claimed to have both behaviourists and cognitive views. His major work was Purposive Behaviour in Animals and Men (1932) which emphasised his view of 'purpose' in behaviour. This entailed the view that we do not merely respond to stimuli, we move towards goals related to our beliefs and our attitudes.

Learning according to Tolman was the acquisition of expectancies. By an 'expectancy' he meant that in the presence of a certain 'sign', a particular behaviour will produce a particular consequence. We 'learn' when we establish a series of expectations concerning the contiguity of events based on repeated past experiences of their appearance in sequence. Learning can occur without reward if the contiguity of stimuli can be repeated often enough. As a person becomes aware of novel behaviour and unsuspected relationships, new behaviour will appear. Tolman referred to this as ' inventive ideation.'

His insistence on learning as 'sign expectation', that is, as resulting from an individual's expectation that the environment is organised in certain ways and that 'one thing invariably leads to another'. has found rise in the theory and practice of teachers who place emphasis on the logical construction of schemes of classroom work.

Skinner (b1904) - The Technology of Teaching (1968) is perhaps his most important recent work. His study of conditions of behaviour of animals and birds as well as children, led to continued experiments in the modification of behaviour by operant conditions.

An organism learns, according to Skinner by producing changes in its environment. At the basis of his view of the nature of the learning process is the concept of reinforcement as a stimulus which increases the probability of a response. Reinforcement can exist in either a positive or negative form. Positive reinforcement is the presentation of a stimulus which, when added to a situation increases the probability of occurrence of a response. Negative reinforcement is the termination of some unpleasant ('aversive') stimulus, which when removed from a situation, increases the probability of occurrence of a response.

It is the conditioning of operant behaviour which is of great importance in his analysis of the learning process. Learning is, in essence, the creation of conditioned connections between the learner's operant behaviour and its reinforcement; it is a change in the form or the probability of responses. The strength of a learned response is generally determined by the amount of reinforcement it receives.

Skinner's direct application of operant conditioning findings to the problems of classroom learning culminated in his advocancy of programmed instruction and the teaching machine. He believed there was every reason to expect that the most effective control of human learning will require instrumental aid. The concepts of immediate reinforcement of emitted behaviour and the gradual withdrawal of stimulus support from the learner ('fading of learning cues'), which characterise programmed instruction were derived direct from his success in the shaping and conditioning of animal learning through reinforcement.

He believes that a student is 'taught' in the sense that he is induced to engage in new forms of behaviour and in specific forms on specific occasions.' The teachers task is to shape behaviour and this requires an awareness of objectives and the techniques of attainment.

Gagne (b1916) - His most important works have been The Conditions of Learning (1965). Essentials of Learning for Instruction (1974) and Principles of Instruction Design with L. J. Briggs (1979).

He describes learning as 'a change in human disposition or capability, which persists over a period of time and is not simply ascribable to the process of growth. It is a process taking place in the learner's brain; it is called a process because is is formally comparable to other organic processes such as digestion and respiration. People do not learn in any general sense, rather in the sense of changed behaviour that can be described in terms of an observable type of human performance.' The change in a student's performance is what leads to the conclusion that learning has occurred.

Gagne views learning as a total process beginning with a phase of apprehending the stimulus situation, proceeding to a stage of acquisition, then to storage and finally to retrieval. The teacher must ensure that a student has the pre requisite capabilities for the learning tasks he is to undertake. There is a learning hierarchy which depends on pre requisite intellectual skills. This serves as an indication to the teacher that the learner must be adequately prepared to enter a particular phase of instruction. The teacher must ensure that relevant lower order skills are mastered before the learning of the related higher order skill is undertaken i.e. the teacher should find out what the student already knows; second, begin instruction at that point.

As a final point Gagne stresses the importance of feedback in the classroom. Every act of learning requires feedback if it is to be completed. This necessitates communication to the student, as swiftly and accurately as possible, of the outcome of his performance, calling for careful and regular evaluation in the classroom. The planning of feedback is one example of the design of instruction with the learner in mind which characterises the neo behaviourism of which Gagne is a powerful advocate.

3.1.3 Gestalt School

This school of psychological theory evolved from the work of:- Koffka (1886 - 1941), Kohler (1887 - 1967) and Werthheimer (1880 - 1943).

The basic theories are set out and elaborated in Koffka's Principles of Gestalt Psychology (1935), Kohler's Gestalt Psychology (1929) and Werthimer's Productive Thinking (1945).

The essence of their approach is that 'the whole is greater than the sum of its parts; we are dealing with wholes and whole processes possessed on inner intrinsic laws.' The complex perceptions which are involved in thinking and learning, are much more than the mere 'bundles of sensations' of which they are said to be constituted. A learner's experience has a pattern, a 'wholeness'. which is more than the sum of its 'parts'. It is a structure of psychological phenomena with properties which cannot be understood by a mere summation of those phenomena.

Phenomena such as learning have to be studied as complex highly organised structures. The aspects of behaviour which we call 'learning' is, in the view a pattern of activities. Fundamental to an understanding of these activities is the concept which the Gestaltists, know as insight.

This can be applied to the teaching in the sense that learners often mentally organise the components of a task and perceive with 'sudden vision' the solution to a problem or, as teachers and students might put it, 'the penny suddenly drops' is a common experience in classroom teaching. Learners commonly select from new material that which seems important, so that new terms emerge leading to insight. That insight becomes more highly structured until it produces a solution to the problem.

The Gestaltists stress the importance of practice and suggest that teachers should consider the advisability of providing for students continued opportunities for the observation of novel pattern and relationships. Awareness and understanding of those relationships can be utilised by the teacher through a series of planned, systematic exercises, so that problem solving can be carried out as Hilgard and Bower (1981) state:-

> 'sensibly, structurally, organically, rather than mechanically, stupidly, or by the running off of prior habits.'

3.1.4 Cognitive School

The cognitive psychologist is concerned with the learner's 'internal processes' in knowing and perceiving. It assumes that a learner's behaviour is based on 'cognition', i.e. acts of knowing or thinking about the very situation in which that behaviour occurs. The formation and use of concepts, knowledge of the environment as the result of interactions by the learner and his surroundings, the organisations of knowledge are of basic interest to the cognitive school. The task of the teacher is related directly to the development of 'cognitive strategies' in the learner, i.e. his capabilities to select and modulate his individual internal processes of thinking, perceiving and learning. Dewey, Bruner and Ausubel are regarded as being leading disciples of cognitive learning.

Dewey (1859 - 1952) Democracy and Education (1916) and The Need for a Philosophy of Education (1934) are two of his major works. He views education as 'intelligent action', characterised by the learner's continuous evaluation of his experiences, the eventual product of which is a redefinition of purposes.' The only 'true education comes through the stimulation of one's powers by the demands of social situations.

Dewey, believed every event, external or internal, calls for some kind of response. All human behaviour is the result of events and is guided by anticipation of consequences and other intervening variants. Behaviour also determines events which follow it. Learning has to be viewed as part of a 'whole'. as part of an interaction of the learner and his environment.

Learning is 'learning to think'. It arises as the result of the 'formation of wide awake, careful, thorough habits of thinking'. The process of learning involves the exercise of the intelligent (every intelligent act involves selection of certain things as means to other things as their consequences' and the comprehending of information so that it can be used in new situations. Mere activity does not constitute experience; 'learning by doing' is impossible unless the 'doing' effects a change in the learner's cognitive structures.

Dewey places a great emphasis on the role of the teacher 'as a stimulus to response to intellectual matters'. Everything a teacher does in the classroom, as well as the manner in which he does it, incites the student to respond in some way or other and each response tends to set his attitude in some way or other. The teacher's influence is paramount even in those situations which Dewey describes as 'pupil centred' (i.e. in which the students personal desired level of attainment and motivations are taken carefully into account. The teachers responsibility for the development of 'reflective thinking' in his students is also emphasised. The motivation of cognitive learning is related directly to the learner's standards of intellectual achievement and to the guidance of his teacher.

Bruner (b1915) - His work has been influenced greatly by the thinking of Piaget, particularly in relation to the development of thought processes. He has many works to his credit, two such being 'Towards a Theory of Instruction (1966)'; 'The Relevance of Education (1973).'

Bruner's view of learning is in terms beyond the mere acquisition of knowledge; he sees its end as the creation of 'a better or happier or more courageous or more sensitive or more honest man.' The teacher Bruner believes should provide problem situations that stimulate students to discover for themselves the structure of subject matter, that is the essential information. Specific facts and details are not part of the basic structure. However, if students really understand the basic structure they should be able to figure out many of these details on their own. In other words Bruner believes that classroom learning should take place inductively, moving from specific examples presented by the teacher to generations about the structure of the subjects that are discovered by the students.

The basic structure of subject matter is made up of concepts. A concept being a category of things that can be grouped together because they are similar in some way. The concept of students for example, refers to all instances that fit into the category of people who study a subject. Concepts are abstractions i.e. student is not but examples of students are. Being able to form concepts and relate them to one another via coding systems makes it possible for people to demonstrate what Bruner (1973) calls the most characteristic aspect of mental life; the ability to go beyond the information given. Bruner (1960) recommends that teachers nurture insight through intuitive thinking. The student should be encouraged to make intuitive guesses based on incomplete evidence, then check out these guesses more systematically. In this way the student will have the chance to practice his or her's ability to go beyond the information give.

However, Bruner's ideas have found major application to classroom teaching and the spiral curriculum idea and discovery learning.

In his spiral curriculum concept Bruner (1960, 66) suggested a radical reorganisation of the curriculum across all grade levels. This would entail the fundamental structure of all the subjects students are likely to encounter throughout the school years would be presented very early in a very simplified form e.g. Maths, Physics, Languages etc. These would be presented in their most simplified specific form in the lower grades and then presented in successively more complex forms in the higher grades. Bruner believes that this progression of subject matter encourages students to discover relationships and form coding systems that they can continue to expand and improve as they encounter the material at increasingly sophisticated levels. The teaching at each level would have to take into account the level of cognitive development of the students. This organisation of the subject matter reflects Bruner's belief that learning proceeds from simple to complex, from concrete to abstract and from specific to general, leads him towards an inductive approach. This is where the student, given specific facts discovers the generalisations, or the structure for themselves.

This was the basis for his idea of discovery learning where the teacher organises the class so that the student through their own active involvement. In discovering the 'meaning' of principles, the student is learning concepts and relationships. Bruner suggests that the activity of discovering has four advantages. First, there is a growth in 'intellectual potency' the student acquires the ability to develop 'strategies' in approaching and analysing patterns in his environment in an organised manner. Secondly, intrinsic motivation becomes a preferred alternative to extrinsic rewards the student achieves satisfaction from discovering solutions on his own. Thirdly, the student who has mastered the techniques of discovery learning is able to apply them to the solution of real problems outside the classroom. Finally, improvement in memory seem to be associated with the organisation of one's knowledge retrieval of information stores in the memory becomes easier where the student has organised his knowledge in terms of his own system.

Ausubel (b1918) His major work is Educational Psychology A Cognitive View (1978). He sees educational psychology as concerned primarily with 'the nature, conditions, outcomes, and evaluation of classroom learning'; His view is that learning should occur through reception not discovery. Teachers should present materials to students in a carefully organised, sequence and somewhat finished form. Students will thus receive the most usable material. Ausubel refers to this method as expository teaching. The use of this method is confined to what Ausubel terms meaningful verbal learning, or the learning of verbal information, ideas and relationships among verbal concepts. The method is not useful in teaching physical skills or such as multiplication tables. Ausubel believes that learning should progress deductively, that is from an understanding of the general concepts to an understanding of specifics. Rote and motor type learning have no place in classroom learning acquisitioning to Ausubel.

The principal factors influencing 'meaningful learning and retention' are according to Ausubel the substantive content of a learner's structure of knowledge and the organisation of that structure at any given time.

Ausubel's expository approach to teaching has four major characteristics. First it calls for a great deal of teacher/student interaction. Secondly it makes great use of examples, although the stress is on meaningful verbal learning. Thirdly it is deductive and finally it is sequential i.e. follows a certain pattern of steps. Essentially these steps are the initial presentation of an advance organiser (which is an introductory statement of a high level concept, broad enough to encompass the information that will follow), followed by subordinate content. This is organised in terms of basic similarities and differences. Then examples are provided of the various subconcepts. The teacher must then help the students to see the relationships between the examples discussed and the general ideas given in the advance organiser. There should be reference throughout a course to previously learned ideas, definitions and principles, so that they are integrated into course content as a whole.

Ausubel's emphasis on 'meaningful learning' will remind teachers that learning designed to ensure master of a situation by an extension of the student's powers of reasoning, involves the careful design of instruction with that end in mind.

3.1.5. Developmental School

This school of psychology centres around the work of Piaget (1896 1980). A major work of his was 'The Origins of Intelligence in Children 1952'. The concept of learning was centred around human development. This involved the development of basic physical, logical mathematical and moral concepts from birth to adolescence (concept growth in such things as number, time, space, velocity, geometry, chance and morality).

Piaget considers that conceptual growth occurs because the child, whilst actively attempting to adapt to his environment, organises his actions into schemata through the processes of assimilation and accommodation.

The schema is an important element in Piaget's theory. Bartlett (1932) coined the expression to describe it as follows:-

'an active organisation of past actions.'

Hebb (1949) uses 'cell assemblies' as the counterpart of Piaget's schemata. When the actions become replaced by symbols (words, numbers etc.) they become known as representational schemata. When a child is able to represent his world mentally by means of memory, imagery or symbolistic language, he is said to have internalised these experiences.

Thought or thinking, according to Piaget, has its origins in actions physically performed and then internalised. Bluntly then, thought is internalised actions. The starting point of cognitive development must therefore the activity on the part of the neonate, not passive reception of sensory data. The child's striving to adapt and structure his experience enables patterns of actions to be formed. At a primitive level, the patterns may be simple perceptual patterns which become internalised. When these are recalled, they reappear as images of the origin experience.

Once symbolic language frees the child from the need to manipulate raw reality in order to form schemata, he can begin to develop logical thinking. He is able to reason using representation of the facts. The ability to carry out activities in one's imagination is known as an operation and, the child's growth to intellectual maturity depends on his capacity to carry out these mental operation.

Piaget's theory was genetic, maturational and hierarchical. Adaption takes place in a set sequence of stages associated with successive mental (not chronological) ages. Several schemes representing the stages exist. The outlines of these are shown in Table 3.1 Appendix 3.

BORK (1985) produced a further classification and summarised the characteristics as shown in Table 3.2 Appendix 3.

3.2 Psychological Models Applied to CAL

Hannon and Wooler (1985) state that:

> 'we should be realistic about what can be expected from psychology.'

There is certainly no such thing as a single coherent 'Psychology of Information Technology.' In order to see the relevance of psychology in this area we need to understand the links between psychology and education generally. Sometimes the application of psychological knowledge results directly in an educational innovation, but on the whole such cases are rare. More often psychology is linked to education because educationalists turn to one psychological theory or another to justify innovations introduced primarily for other reasons. In other cases psychology enters education because, implicitly or explicitly; psychological benefits are claimed for certain educational practices. We also find psychological concepts used in describing certain curricular innovations which can, on occasions, be appropriately evaluated by means of research techniques imported from psychology. Psychology can be linked with the emerging educational fields of computing and information technology in all of the above ways.

Much has been said about the use of the microcomputer as an educational tool, but relatively little attempt has been made to place this use within particular models of cognitive development. Mills (1984) points outs:

> 'not only can CAL be categorised according to the degree of user control permitted to the learner, but also particular implementations often reflect differing models of learning and, hence, of cognitive development.'

It is a fact however, that these models are rarely made explicit by the programme designers. With this background in mind we draw from the psychological schools previously discussed models of learning which have been applied to the development of Computer Assisted Learning (CAL) resources, and in subsequent sections to what extent.

There are six main models:

1) IPS or Computer Model

2) Skill Model

3) Hierarchy Model

4) Framework Model

5) Feedback Model

6) Ausubel's Model

3.2.1 IPS OR COMPUTER MODEL

The Information Processing system theory of learning is a computer based model. It puts learning and memory together where traditionally they have been separated and treats them as two sides of the same coin. The model forms the basis of information processing theories. Anderson and Bower (1973), Atkinson and Stuffurin (1968), Rumbelhart, Lindsay and Norman (1972). It postulates a number of internal structures in the human brain and some corresponding processes that they carry out, and highlighted by Greeno and Bjork (1973).

A version of this model is shown in Figure 3.1, Appendix 3.

The learner receives stimulation from the environment, which activates his receptors and is transformed to neural information and passed to the sensory register for a brief interval (some hundredths of a second), from which they may be processed by selective perception into perceived objects and object qualities, or features. This 'information' may then be stored in short term memory as auditory, articulatory, or visual images which are subject to rehearsal. As input to the long term memory the information is semantically or meaningfully encoded, and then stored in this form. Processes of search may be instituted followed by the process of retrieval. At this point, the information may be returned to the short term memory, which is conceived as a 'working' or conscious' memory. From this structure or directly from long term memory, the response generator is brought into play to generate a suitable response organisation. The signal flow from this structure activates effectors which exhibit the human performance. Feedback is provided via the learners observations of this performance and the phenomenon of reinforcement establishes the learned entities as capabilities available for future recall, exercise and uses. The diagram illustrates this feedback process. Our model described above provides a conception of the internal events of learning. In computer language these processes might be called 'routines'. Obviously though as they occur in human learning they have a richness and complexity that goes beyond their basic functioning. The ways in which an individual learner may approach, engage in, and execute an act of learning all display the characteristics of variability, flexibility and ingenuity.

The way in which these qualities of learning and remembering and generalising are to be conceived and brought into the total picture are via the executive control processes and expectancies. Both processes have been largely acquired by the individual in previous learning. For that reason they constitute another separate portion of long term memory. Their function is to determine or choose the particular kinds of information processing in which the learner engages to accomplish particular kinds of learning tasks. In other words they determine the learner's approach to one or more ways of processing information, how he goes about attending and storing and encoding and retrieving information. The executive control processes and expectancies are not connected with other structures in the model. This incompleteness indicates that these control processes are capable of affecting any and all of the phases of information flow. Control processes influence attention and selective perception by determining what features of the contents of the sensory register will be entered into short term memory and how information is stored in long term memory. Also they can have an affect on how well one remembers. They probably also have an affect on the choice of a format for responding and so influence the kind of response organisation chosen for the learner's performance. They determine also the learner's strategies for generalising and problem solving and so influence the quality of the individual's thought.

Expectancies are another sub class of executive control process. They represent the specific motivation of learners to reach the goal of learning which has been set for them or which they have set for themselves. What learners need to accomplish can influence what they attend to, how they encode the learned information and how they organise their responses. An expectancy is a continuing set, orientated towards the goal accomplishment, which enables learners to select the outputs of each processing stage. The two interrelated sets of processes described above play crucial roles in any information processing account of human learning and memory. It is apparent to the theorists who use the model shown in Figure 3.1, Appendix 3, that learning and remembering cannot be fully accounted for in terms of a simple diagram of information flow. There must also be processes by which the learner selects the nature of processing at each of the stages show. How the attention of the learner is directed, how the information is encoded how it is retrieved and how it is expressed in organised responses are all matters that require a choice of strategies. This choice is the function of the executive control processes, including the expectancies which have been established before learning is undertaken. Gagne (1977) states:

> 'These processes have the effect of making the learner a truly intelligent being one who can 'learn to learn', and therefore one who can engage in a large measure of self instruction.'

Control processes must themselves be learned.

3.2.2 The Skill Model

Learning as a product of acquiring skills is often said to be attributed to the neo behaviourist school and in particular is exemplified by the work of Skinner (1968).

General skills are acquired in the development of those class of skills (abilities) recognised making up general intelligence. Psychological theory indicates that many such skills are normally overlearned by most children in the normal course of their educational development. Additional practice after overlearning has occurred produces relatively little effect on their performance in intelligence tests and accounts for the relative stability of IQ ratings. As Hebb (1949) has pointed out that:

> 'innate potential for development of the abilities contributing to intelligence is not logically a guarantee that the development will occur ... experience is essential.'

This inevitably leads to the conclusions that for pupils to develop to the full their natural potential referred to as 'Intelligence A' by Hebb, they should be encouraged to overlearn all the skills which contribute to intelligence.

These general skills have been grouped by Thurstone (1938) into seven 'primary' abilities of:

1) perceptual speed.

2) association memory.

3) verbal comprehension.

4) word fluency

5) number manipulation.

6) space visualisation.

7) logical reasoning.

Many psychologists now believe that the above classification is too simplified. Thompson in Wiseman (1967) has suggested that it is possibly chance that abilities can be factorised into so few elements. Burt (1955) has also criticised Thurstone on the basis of his researches which indicated a much more complex pattern and Guilford has postulated a matrix of perhaps over 120 individual abilities. Many of these skills are acquired between the ages of four and ten although Burt and others have pointed out that logical reasoning skills are acquired over a much longer period.

The experimental work of the neo behaviourist Skinner (1968) briefly discussed in section 3.1.2, indicates that techniques for the precise control of reinforcing effects to control behaviour are now available. He has used these techniques to train animals to perform three of four well defined responses in any experimental session, and claims these techniques can be used in human learning. His method is called 'operant conditioning' because the animal has to operate on the environment before obtaining a reward (provided externally) i.e. Response Reinforcement. According to Skinner, if a new skill or element of knowledge to be learned by a human being is followed by some preferred or rewarding activity, but only if the learning has been successfully achieved, this is the basic prototype of learning. Also, a learner who begins with a liking for the 'reinforcement' will transfer this liking to the learning task. To initially learn a response, he suggests that positive reinforcement follow the response each time it occurs. However, he has found that once a predetermined level of responding has been reached, several different schedules of reinforcement are more effective than continual reinforcement. These schedules are known as interval and ratio schedules, and each may be administered in a fixed or variable manner. Thus a fixed interval reinforcement would provide reinforcement following the correct response according to a schedules time plan (such as every two minutes or every two hours), no matter how many responses were emitted during that period. Similarly, fixed ratio schedules provide reinforcement every fifth or tenth response etc. Bower and Hilgard (1981) state that:

> 'Variable schedules provide reinforcement on a random basis, either varying by time variable interval reinforcement or by number of responses variable ratio reinforcement.'

Skinner's latter work dealing with complex human learning emphasised the analysis of the task into small, discrete objectives so that repeated reinforcement could be applied to simple discrete responses. He stressed that students be given tasks in a hierarchy so that they would learn essential components first, and so that they would not fail.

3.2.3 The Hierarchy Model

When operating in the real world, skills must be applied to specific situations or tasks. Understanding the context in which one operates requires subject based learning. A clear line between general skills and subject based learning is impossible to draw because of the considerable overlap in such fields as numeracy and literacy. Cattell (1940) however, states that:-

'Nevertheless, in practice one can define subject based learning as learning which, whether absent or present, would have almost negligible effect on IQ ratings and measured by culture free tests.'

In constructing learning programs for subject based material, Gagne's theory forms a useful basis. In Gagne (1977), he postulates a hierarchy of learning processes from the simplest to the most complex. Figure 3.2, Appendix 3 illustrates the general pattern of his classification of these process.

He considers stimulus response and chaining to be basic forms of learning and the others to be 'intellectual skills.' Gagne defines discrimination learning as acquiring the following:-

'... a response which differentiates by name or otherwise the stimulus features of a single member of a set from those of other members, or ... to distinguish several different members of a set, making a different response to each.'

Discrimination must inevitably be involved in learning to classify different items under the same heading. This latter is one of the essential features of concept formation.

Two types of concept learning are distinguished by Gagne, concrete and defined. A simplified summary of the distinction might be that concrete concepts relate to the classification of the perceived objects through discriminatory learning defined concepts relate to abstract ideas or events which need to be classified according to rules. One method of defining a rule is by a statement such IF concept A AND concept B THEN concept C. This would be a relatively simple rule. A more complex rule might be: IF concept D AND concept E AND NOT concept F THEN concept G ELSE concept H.

Gagne had identified five main categories of learning outcomes that he believed represented all types of learning 1) intellectual skills which incorporated discrimination, concept formation and rule learning as indicated above 2) cognitive strategies (capabilities that govern the individuals own learning, remembering and thinking behaviour), this would include applying rules to problem solving situations. 3) Verbal information. 4) Motor skills and 5) attitudes.

Within these various types of learning, Gagne expressed his belief that there must be nine events of instruction. The internal learning processes (expressed in terms of cognitive theory) and the external instructional events related to these complimentary learning processes. These are listed in Figure 3.3, Appendix 3.

Gagne, Wager and Rojas (1981) and Gagne (1970, 1975) referred to those objects which stimulated learning as 'objects of instruction' i.e. stimuli from which concepts could be taught or derived. Although Gagne is a psychologist in the learning theory mould, his model of learning is essentially of the hierarchical type in which complex cognitive abilities are based upon the mastery of simpler skills.

Piaget's particular model of cognitive growth broadly speaking has the central proposition that learning takes place via interaction with a learning environment which, in some sense, embodies what is to be learnt. As a result of the interaction with a learning which, in some sense, embodies what is to be learnt. As a result of the interaction, the learner, constructs a set of internal hypotheses (or schemata) about the nature of the world. These schemata Evans (1967) states, then act as a:-

> 'set of rules serving as instructions for producing a population prototype.'

Subsequent information is then processed within the existing schema which adjusts in order to cope with dissonant information. Although the schematic model of learning implied above is often associated with recent cognitive theorists its origins can be traced to Piaget's ideas on assimilation and equilibration. For Piaget, assimilation was the integration of the experience of reality into an intellectual structure and equilibration was the process of schema modification in order to compensate for the disturbances caused by moral information. In the above model development, occurs as a progression through a series of stages, each characterised by its own form of equilibration. An essential element in this model is that learning is only possible if a complex structure is based on a simpler structure. This notion remains one of the most significant aspects to emerge from Piagetian Theory, yet it seems that the Piagetians themselves seemed to overlook its significance for the design of their own observational studies. The overall conclusion to emerge from a wealth of studies was that many Piagetians failed to take account of the child's state, the child's world knowledge, or to pose questions that made sense to the child (i.e. could be processed within existing schemata). These failings resulted in an underestimation of children's mental abilities.

This research tradition, generally associated with Bruner's model of cognitive growth has indicated that the claims for the strict interpretation of stage theory have been unfounded and that children are considerably less limited than originally supposed. In all cases this re interpretation of children's abilities has been based on studies which have presented tasks to children in a manner which either made sense to the child or removed unnecessary confusing elements in the testing procedure (see Donaldson (1978), for a review of such investigations).

Although Piagetian and Brunerian approaches are often considered to be at odds, there are essential similarities between the models. Both are basically hierarchical models in which cognitive growth is an ordered process from simple to complex and this development is based upon interactions with the environment and the learner is presumed to be an active participant in the learning process.

Social learning theory has attempted to combine cognitive and behaviourist psychology with its own special emphasis on the person in the social setting with all of its ramifications. Bandura (1977) states that:

> 'Most human behaviour is learned observationally through modelling: from observing others, one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as a guide for action. Because people can learn from example what to do, at least in approximate form, before performing any behaviour, they are spared needless errors.'

He pointed out that observational learning is governed by four component processes 1) attention 2) retentional process, 3) conversion of symbolic representations into appropriate actions and 4) motivational processes. According to the social learning view, observational learning occurs through symbolic processes during exposure to modelled activities before any responses have been performed and does not necessarily require extrinsic reinforcement. It does play a role in observational learning, but mainly as an antecedent rather than a consequent influence. Anticipation of reinforcement is one of several factors that can influence what is observed and what goes unnoticed. This is not really an hierarchical model, but is included here as it spans the behaviourist and cognitive models and is significant in CAL as will be shown later.

3.2.4 The Framework Model

The above possible classifications of course do not tell us how the learning actually takes place. Although, the work of Bruner and Piaget would appear to tend towards this line of approach. Piaget has pointed out that real understanding of concepts and abstractions will only occur when the learner has reached a certain learning stage. The child must already have a set of learning frameworks available within which new learning can be assimilated. Norman and Rumelhart (1975) categorised three modes of learning:-

1) 'accretion' The addition of new knowledge to existing schemata. The framework exists, but new data is entered.

2) 'structuring' the formation of new conceptualisations when existing schemata will no longer suffice.

3) 'tuning' the fine adjustment of knowledge to a task which occurs when the appropriate schemata exist and the necessary knowledge is within them, but they are inefficient for the task at hand because they are too general or not matched to the particular task.

In these terms 'accretion', the most common form of learning, is equivalent to 'assimilation', and 'structuring' to 'accommodation'. Schank (1982) developed a theory of dynamic memory based on his work in Artificial Intelligence. His main point is that memorising is not enough, but that the learner must have a context into which to place newly acquired information in order to make intelligent use of the incoming data. Schank refers to the existing frameworks as 'scripts' and argues that the most efficient learning takes place when we remind ourselves of a previous script and modify it in accordance with a new learning experience. There are close similarities with the statement of Norman's (1982) that:-

'knowledge does not imply understanding'.

The latter comes when the former is interrupted in the light of existing conceptual frameworks.

3.2.5 <u>The Feedback Model</u>

The idea of using feedback control system as a model for a human operator was proposed by Craik (1948) and later elaborated by Hick and Bates (1950). At the same time

Wiener (1948) had been developing the concept of negative feedback in his theory of cybernetics. This model seems to be of special application where the learner's responses produce actions which can be perceived as measurable on an analogue scale. Thus acquiring a skill in controlling a physical action is a process of learning how to 'correct' responses in order to produce the required behaviour. Of course, if repetitive tasks are required to be undertaken the performer's action need not be modified provided there is no error.

3.2.6 Ausubel's Model

We discussed Ausubel's theories of meaningful learning,in section 3.1.4. Ausubel (1968), states that:

> 'the degree of meaningful, as opposed to rote learning of new materials requires its interaction with previous knowledge.'

To aid this process, Ausubel suggests that prior to instruction, organising material of greater generality should be studied by the learner. Such a process of development requires the student to assume a greater responsibility for managing his own learning. The forms of meaningful learning as viewed in Ausubel's Assimilation Theory, Entwistle (1981); are summarised in Figure 3.4, Appendix 3.

Ausubel (1978) gives a good summary of his work in making the distinction between rote and meaningful learning. He suggests that 'meaningful learning' takes place if the learning task can be related in non arbitrary substantive (non verbatim) fashion to what the learner already knows, and if the learner adopts a corresponding learning set to do so.' whereas 'rote learning occurs if the learning tasks consist of purely arbitrary associations ... if the learner lacks the relevant prior knowledge necessary for making the learning potentially meaningful, and also (regardless of how much potential meaning the task has) if the learner adopts a set merely to internalise it in an arbitrary, verbatim fashion.

From his work Ausubel produced a model distinguishing two independent axis called learning as shown in Figure 3.5, Appendix 3.

This illustrates a continuous variation in the learning process from rote to meaningful learning. The second axis although deemed learning has more concern with teaching strategies.

The way in which these models of learning are used in the development of computer assisted learning are outlined in Chapter 5.

CHAPTER 4

LEARNING AND TEACHING STYLES

4.1 Learning Styles

It is clear from the learning theories and models of Chapter 3, that the learning process can be understood to some extent, and therefore, can be guided. However, another important factor arises, in that, any problem with which the student is posed may have different strategies for obtaining a correct solution. Different students also possess personal preferences about the approach to adopt to enact a solution. Clearly students exhibit different learning styles.

There are clear significances for CAL from the above. If as inferred in Chapter 3, Section 3.2 that learning models reflecting different cognitive developments can be related to particular CAL implementations then there must be a possibility of matching CAL to the students of different learning styles.

This has effectively put CAL in a teaching role and therefore, there are certainly significances in the teaching strategies used. Much can be learned from these to assist in this matching of CAL to the student. These strategies will be considered in Section 4.2. However, in the subsequent paragraphs the different learning styles will be considered.

Hudson (1970) distinguishes between two types of students 'the sylbs', who are syllabus bound and the 'sylfs', who are syllabus-free. Some like to be told what to study; others like plenty of choice in the matter.

Perry (1970) in his descriptions of the intellectual and ethical development of students during their four years at Harvard echoes Piaget's observations of young children, notes a progression of much consequence here. It illustrates how a student often begins with the expectations that knowledge consists of right answers, one per problem, and his teacher will tell him what they are. Later on he may recognise that teachers appear to be presenting several right answers to the same question, but he assumes this is a teaching technique to help him find the real right answer for himself. It is some time before he conceives of knowledge as relativistic and dependent on context and comes to see several answers can be right, not because everyone's entitled to his opinion, but because they can be justified in particular frames of reference.

Only those students who are well on the way towards this relativistic viewpoint are likely to commit themselves to purposes of their own.

The work of Pask (1976) and his associates has sharpened our awareness of another difference, that between 'serialist' and 'holist' learning. Students using a serialist strategy work through a topic step by step in linear sequence. Their focus is narrow and they prefer to learn each item thoroughly before going on to the next. In recalling what they have learned they will usually follow their original sequence. Students adopting a holist strategy on the other hand, try to roam freely over the topic, examining it from many viewpoints, looking for analogies and examples, and building up a general picture before attempting to learn details. Robertson (1977) states:-

> 'they also have a wide focus of attention bringing together several sub-topics right from the start.'

In the end both groups of students can reach the same level of understanding, but their ways of reaching that understanding are very different. The serialists apparently put much emphasis on the separate topics and the logical sequences connecting them, forming an overall picture of what is being learned only rather late in the process. The holists try to build up that overall picture, as a guide to learning, right from the start and see where the details fit into that picture much later on.

Pask distinguishes two major pathologies of learning - the failure to examine the logical structure or the evidence in sufficient detail, and the failure to make use of appropriate analogies. He attributes as 'globe trotting' the tendency of the holist to make inappropriate or vacuous analogies. This pathology might also take the form of an over readiness to generalise from insufficient evidence to form hasty personal judgements. The serialist falls into the opposite trap. He fails to make use of valid and important analogies and may not build up for himself any overall map to see how the topic fits into the subject area in general. This pathology is referred to by Pask as improvidence.

The general tendency to adopt a particular strategy is referred to as a learning style, see Pask (1976). The 'holist like' style is called comprehension learning which involves 'building descriptions of what is known.' The 'serialist like 'style is called operation learning, which is the facet of the learning process concerned with 'mastering procedural details.'

Students who show sufficient consistent bias in their learning strategies to be described as 'comprehension learners' or 'operation learners' are likely to show equally consistent pathologies of learning. There are, however, other students who are readily able to adopt their learning strategy to the requirements of the particular task, emphasising either comprehension learning or operation learning as appropriate, and using both in tandem wherever possible. Pask describes these students as having a versatile style of learning, not prone to globe trotting.

Matching familiar figures, Kagan et al (1964) and Identifying Embedded Figures Witkin (1977) were tests where the respondent is required to answer as quickly as possible, making another attempt after each incorrect answer response. There is not only pressure to find correct answer, but also to decide quickly. Kogan (1976) sees the situation as building up competing anxieties towards correct, or fast, responses. The average time to answer (response latency) is measured and also the number of errors. Two cognitive styles have been detected with these tests. Impulsive people succumb rapidly to the need to identify the matching figure: they choose timidly and make more mistakes. Reflective individuals treat the task more analytically and cautiously: they are more accurate, but slower. Among children there is again a developmental trend, as well as a cognitive style component in these measures. Fast accurate children are often intellectually more advanced than slow, inaccurate children, but the impulsive/reflective distinction according to Messer (1976) does seem to indicate an important difference in information processing strategies. Kagan (1966) carried out tests which produced results as shown in Table 4.1, Appendix 4.

With semantic material speed and accuracy are related to intelligence, but differences in scores produced on 'speed' and 'power' tests of reasoning show that some intelligent people prefer a careful thoughtful response.

This would tend to indicate the trend of Table 4.1. Appendix 4.

Witkin (1976; 1977) reviewed extensive literature on the uses of the embedded figure test and other methods of measuring the dimensions of field dependence/field independence. In the E.F.T. some people can spot the embedded figure almost immediately; they are not distracted by the surroundings and are categorised as field independent. Other people spend much longer with simple items. Witkin labelled the styles of thinking as articulated (field-independent) and global (field-dependent), which seem to bear some resemblance to Pask's description of operational and comprehension learning.

Articulated field-independent style involves analysing and structuring incoming information; the global, field dependent mode of operation accepts the totality of impressions. Witkin et al (1977) summarises field dependent and independent as follows: field-dependent as using social cues preferring personal and social activities, requiring guidance, material and feedback on learning progress, profiting from filmed material. The field-independent uses on the other hand mediating strategies preferring impersonal strategies needing little guidance and feedback; profiting from written material.

Guilford (1950) introduced his 'model of the intellect', he postulated several cognitive operations amongst which he included convergent and divergent thinking. The convergent thinker is distinguished by his/her ability in dealing with problems requiring one conventional correct solution clearly obtainable from the information available. Problems of this kind can be found in all intelligence tests and many 'objective-type' questions in which a problem is presented with several solutions only one of which is correct. There is no opportunity given for productive thinking in such cases beyond the information supplied; in fact, items with more than one solution would be discarded as unsatisfactory.

The divergent thinker on the other hand is adept in problems requiring the generation of severally equally acceptable solutions where the emphasis is on the quantity, variety and originality of responses. Divergent thinking has often been correlated to creative thinking? The two categories being an attempt to discriminate between the style of problem solving behaviour adopted in closed and open-ended problems.

Hudson (1966) drew attention to the wide differences in performance on the Uses of Objects Test, even of sixth formers who were all highly intelligent. The inability of some pupils to think of more than the most obvious uses led Hudson to designate them as 'convergers', while the super abundance of uses produced by other boys indicated that they could be called 'divergers'. The label given depends on which test score was higher - the verbal reasoning test or the open-ended test. Hudson (1970) came to the conclusion that when such tests are combined convergers were more than twice as likely as the divergers to be academically successful. He also categorised the above types in terms of their personality characteristics. Convergers were authoritarian, masculine, unemotional and sober. Divergers on the other hand, are liberal, feminine, emotional and humourous. Also Hudson observed that the majority of convergers studied science while divergers mainly specialised in the arts.

Heath (1964, 1978) in his work at Princetown University identified four types of student personality wise; X-non committers - marked tendency to avoid involvements, taking a passive role in a conflict situation. Y-type hustler: thrives on activity, but is is purposeful activity. Also he seems to possess an inordinate need for achievement, for concrete success. Z-plungers; in contrast to X, who maintain a remarkable stability of mood, Z is known for a variability of mood. Today he may feel on top of the world, tomorrow might find him/her bitter, sad and alone. The final type if A-reasonable, adventurer; has ability to create his own opportunities for satisfaction. He/she seems to have their psychological house in sufficient order to release him to attack the problems of everyday life with zest and originality.

A student may sometimes seem more or less wedded to one strategy or another, as an expression of a more general learning style, itself perhaps related to some dimension of personality. Also the student may be flexible enough to switch from one strategy to another according to the nature of the task in hand.

Ference Marton and colleagues at Gothenburg University have helped throw interesting light on the way in which students may adapt their approaches according to how they perceive a certain task and what they hope to get out of it.

Dahlgren and Marton (1978), Marton (1975), and Marton and Saljo (1976) from their interviews with students on completion of a learning task, they were able to distinguish between what they called 'surface-level' and 'deep-level' approaches to learning. The surface level approach is passive and shallow with the students looking for isolation facts or ideas that he can learn by rote on the assumption that, these are what he will be questioned on. Students using a deep-level approach, however, are those who attempt to penetrate the surface of the material, looking for an underlying theme or message, trying to evaluate the contents in terms of their own previous experience of related matters. Larillard (1979) reported that two thirds of her sample of students which she had studied used different approaches on different occasions.

Kogan (1976) comments that:-

> 'the cognitive styles are not to be taken for granted neither being completely independent nor completely overlapping in their interrelationships.'

Entwistle (1981) in the absence of firm empirical relationships attempted to marry some of the learning strategies in the following manner. Holists tend to be divergent thinkers, which might imply they use wider conceptual categories, and are more ready to accept thematic as opposed to analytic links between concepts. It might also imply that they are likely to be impulsive, emotionally uninhibited but not anxious, and to opt for courses in languages or in humanities. Serialists are more convergent in their thought processes. They are thus likely to be cautious, conservative, analytic and tend to reject possible connections buy using narrow categorisations. Emotionally they might be inhibited and their area of study is likely to be mathematical or scientific. Versatile learners are surely cognitively complex. They can vary their strategy according to the characteristics of the task, and presumably are able to withstand diversity and inconsistency.

What is clear from the various researches into learning strategies is that our 'student body' can never in fact be regarded as one monolithic mass whose every member can be expected to react to 'course offerings' in a uniform manner.

They will differ among themselves in their styles and orientations to learning: some will be at a higher stage of intellectual development than others; some will be more independent and willing to take initiative; some will be collaborative with other students, some will be competitive and some will simply want to be left alone to get on with it; some will be interested chiefly in mastering the subject, others more in getting good grades; and so on. Furthermore, any individual student is likely to have a different range of strategies to draw on for any given learning task. Honey and Mumford (1989) have more recently produced a very good overview of learning styles in the form of general descriptions as follows:-

Activists - They involve themselves fully and without bias in new experiences. They enjoy the here and now and are happy to be dominated by immediate experiences. They are open-minded, not sceptical, and this tends to make them enthusiastic about anything new. Their philosophy is; 'I'll try anything once.' They tend to act first and consider consequences afterwards. Their days are filled with activity. They tackle problems by brainstorming. As soon as the excitement from one activity has died down they are busy looking for the next. They tend to thrive on the challenge of new experiences, but are bored with implementation and longer term consolidation. They are gregarious people constantly involving themselves with others but, in doing so, they seek to centre all activities around themselves.

Reflectors - like to stand back to ponder experiences and observe them from many different perspectives. They collect data, both first hand and from others, and prefer to think about it thoroughly before coming to any conclusion. The thorough collection and analysis of data about experiences and events is what counts so they tend to postpone reaching definite conclusions for as long as possible. Their philosophy is to be cautious. They are thoughtful people who like to consider all possible angles and implications before making a move. They prefer to take a back seat in meetings and discussions. They enjoy observing other people in action. They listen to others and get the drift of the discussion before making their own points. They tend to adopt a low profile and have a slightly distant, tolerant unruffled air about them. When they act it is part of a wide picture which includes the past as well as the present and others' observations as well as their own.

Theorists - Adapt and integrate observations into complex , but logically sound theories. They think problems through in a vertical step by step logical way. They assimilate disparate facts into coherent theories. They tend to be perfectionists who won't rest easy until things are tidy and fit into a rational scheme. They like to analyse and synthesise. They are keen on basic assumptions, principles, theories, models and systems thinking. Their philosophy prizes rationality and logic. 'If it's logical its good'. Questions they frequently ask are; "Does it make sense?" "How does this fit with that?" "What are the basic assumptions?" They tend to be detached, analytical and dedicated to rational objectivity rather than anything subjective or ambiguous. Their approach to problems is consistently logical. This is their 'mental set' and they rigidly reject anything that does not fit with it. They prefer to maximise certainty and feel uncomfortable with subjective judgements, lateral thinking and anything flippant.

Pragmatists - Are keen on trying out ideas, theories and techniques to see if they work in practice. They positively search out new ideas and take the first opportunity to experiment with applications. They are the sort of people who return from management courses brimming with new ideas that they want to try out in practice. They like to get on with things and act quickly and confidentially on ideas that attract them. They tend to be impatient with ruminating and open-ended discussions. They are essentially practical, down to earth people who like making practical decisions and solving problems. They respond to problems and opportunities 'as a challenge'. Their philosophy is: 'There is always a better way' and 'If it works its good.'

4.2 Teaching Styles

Teachers differ in their professional world-views-their pedagogic paradigms, such differing 'pedagogic paradigms' are compounded out of various beliefs teachers hold about education, knowledge, students and the processes by which they are assumed to learn. One tends to look at teachers views as a continuum. One extreme is characterised by the teacher whose first loyalty is to a public corpus of pre-existing knowledge, which he knows every student ought to acquire and whose concern is to 'get it across' to a succession of students who learn, as far as their limited capacity and motivation will allow by absorbing and reproducing the products of other peoples' expert experience. Many teachers who would not publicly or even consciously, subscribed to such notion, nevertheless as though they do in their teaching and especially perhaps, in the ways in which they assess students learning.

The other extreme is characterising by teachers who eschew generalisations about what every student ought to learn and who believing people to have unlimited capacity for growth unless 'discouraged', give their first loyalty to individual students, encouraging them to develop their own motivation and pursue their own purposes in enjoying, and getting better at, the process of making their own meanings and creating new knowledge out of their own ideas and experiences.

To put it into context, where one extreme sees students as passively responding to received knowledge, the other concedes them as an active role in making knowledge, at the very least by filtering what we tell them through their own experience and forming their own conclusions. Few teachers /lecturers are likely to dig in at either extreme of the continuum. Most of us tend, in general, to edge towards one rather than the other. However, each of us is likely to vary his position according to the particular aspect of education in question; according to the subject we are teaching or even from topic to topic within it, according to how we see a particular group of students.

There are in the main two broad contrasting approaches to education and training within the context of which virtually all important educational technology-related developments in particular CAL, have taken place, namely, the traditional teacher/institution centred approach (formal teaching environment) and the more recent student-centred approach (informal teaching environment). In each case we will first examine the structure of the system that underlies the approach, finally discussing the main teaching methods used by both approaches and their strengths and weaknesses.

4.2.1 Teacher/Institution Centred Approach

In the conventional teaching/learning situation, the teacher imparts, to a class of students subject matter which is laid down in some form of syllabus (or, more often than not, imparts his personal interpretation of the syllabus). According to Entwistle (1981) they see their role in terms of:-

> 'the narrow view of education in which examination results and vocational training are dominant.'

The classes normally take place at set times and last for a pre-determined period, as indicated by a timetable while the teaching methods are almost invariably of the 'face-to-face' type. The whole system is geared towards the smooth operation of the teaching institution, with little or no attempt being made to cater for the different learning styles and particular difficulties of individual students.

A schematic representation of the traditional teacher/ institution centred approach to education and training is given in Figure 4.1, Appendix 4.

In such a system virtually all the decisions as to how a course is to be organised and taught are made either by the institution mounting the course or by the teacher nominated to take the class. The institution decides where and when the class is to meet and how long each session is to last, these arrangements being tailored to fit in with those for all the other courses run by the institution. The institution also decides which particular member (or members) of staff will be responsible for actually teaching the class.

The teacher or instructor makes most of the 'tactical ' decisions relating to how the syllabus (which is often laid down by an external body of some sort), should be interpreted, in terms of both the specific subject matter to be covered and the level of sophistication at which this is to be treated. Decisions regarding the structuring, sequencing and presentation of the material are also made by the teacher, as are decisions concerning the teaching methods to be used and the pace of the course.

The student normally has little or no say in any of these decisions, and must try to adapt his learning style to the organisational constraints laid down by the institution and to the educational decisions made by the teacher. Finally the student's ultimate achievement on the course is normally assessed by an examination of some sort, sometimes set externally, with the individual student again having no say regarding how this is done.

4.2.2 The Student-Centred Approach

While conventional teaching strategies are strongly dominated by the teacher and by institutional constraints, student-centred strategies are designed to provide the student with a highly flexible system of learning which is geared to individual life and learning styles. In such strategies, the teacher and the institution play supportive, rather than central roles.

This learning strategy owes its above title to Rogers however, many such phrases have been coined to refer to this informal alternative approach to traditional style teaching strategies. Typically Enquiry (Socrates); Experimental (Dewey); Humanistic (Weinstein); Confluent (Brown); Androgogy (Knowles); Progressive (Bennett); Active Tutorial Work (Button); and Participatory Learning. However, Peters (1987) characterises it in a more general description as 'the students being given the responsibility for their own learning. Rather than purely relying on the teacher to spoon-feed them with information they should be encouraged and made to feel that they should take charge of their learning.' By making them more responsible they should be better motivated and feel a sense of duty to get work done. Students often like to be given responsibility in this way. Other useful skills for their future are also developed such as the ability to plan and organise their time, use sources of information efficiently, make decisions and solve problems. Student-centred learning is also characterised by the students being active and participating in the learning process, acquiring knowledge for themselves rather than being told. It is often more meaningful to actually experience something by doing and learning is often increased. Being active helps stimulate students and keep their interest. Also this type of teaching strategy can and often does, involve the students in negotiation.

A wide range of approaches has been developed and used at different levels of education. These vary from systems designed to individualise learning within an existing educational or training environment by extensive use of resource-based learning, to systems where practically all of the conventional barriers to educational opportunity have been removed, so that a potential student can be of any age or background, and can study in places, and at times which suit the individual rather than the institution. Such systems are called open learning systems, and are at present engendering a great deal of interest within the further and higher education and training sectors in the U.K.

The basic structure of the system that underlies the student-centred approach can be represented diagramatically as shown in Figure 4.2, Appendix 4. Although not all of the factors shown are applicable in every case.

In such a structure, the individual student's requirements are the most important considerations, with all the other components of the system being geared to assist the student to achieve his particular learning objectives as effectively as possible.

The relationship between the student and his host institution can vary considerably within the context of the student-centred approach. However, at least three basic organisational systems can be identified namely institution-based systems, 'local' systems and distance learning systems.

Institution-Based Systems - In this system the students work at a particular institution, with learning facilities and lecturer/teacher help being provided by the institution on an 'open access' basis, and the students attending the institution for study at times and at a pace which suits them. A classic type of this is the Keller Plan as outlined by Percival and Ellington (1984).

Local Systems - The host institution sets out to offer the students the facilities normally associated with a correspondence course and to back this up with on-the-spot institutional support. Such systems are aimed specifically at members of the local population whose personal situations render it impossible to attend the formal education courses. Regular attendance at the college is not required since a range of individualised learning facilities are provided on an open access basis. A typical example of this type of system is 'Flexistudy', which is becoming increasingly popular in the U.K., especially in the field of further education. This has its works in the Manpower Service Commission's 'Open Tech' Programme.

Distance Learning Systems - Most of the learning takes place away from the host institution. Individualised learning materials are provided for the student, and tutorial help may be made available through correspondence with the institution or via a local lecturer/teacher or both. Self help groups organised by students in a particular geographical area may also spring up. The best known example of this is the Open University in the U.K.

In all of the above mentioned systems the student has a high responsibility for all aspects of his/her own learning. This necessitates a high level of motivation.

4.3 Matching of Teaching and Learning Styles

Entwistle (1981) outlined Pask's investigation of matching and mismatching learning material with student's learning strategies. Results were dramatic although they were only based on a small sample. There was little overlap in the scores of the matched and mismatched groups. Students in matched conditions were able to answer most of the questions about what they had learned, whereas other students generally fell below half marks.

A new area of research notably aptitude treatment interaction was initiated when Cronbach (1957) criticised the separation between psychologists who studied learning and those who measured abilities. He argued that we should expect differential effects of contrasting education 'treatments' on students with differing aptitudes, whether it be an intellectual skill or personality characteristic. Biggs (1976); Snow (1976) and Gustafsson (1976) although accepting that the idea made intuitive sense, state that it has proved difficult to find aptitudes on which there are consistent differential effects. Aptitudes such as verbal reasoning,which are closely related to school learning more often than not, do not produce differential patterns because, whatever the 'treatment' the pupils with the highest reasoning scores also show higher levels of performance.

Leith (1974) and Trown and Leith (1975) have demonstrated interesting interactions between personality classroom organisation and teaching methods. Figure 4.3, Appendix 4 illustrates some typical results. Clearly it would appear that anxious students learned more effectively from a teacher-centred supportive strategy while the emotionally stable students were more successful with a learner-centred exploratory approach. The 'cross-over' effect could be used to allocate students to treatment although such 'streaming by personality' can create other problems and is rarely advocated.

Radatz (1979) carried out tests to investigate differences between student/teacher streaming strategies in the areas of arithmetic skills and set language. The results of this research are shown in Figures 4.4 and 4.5, Appendix 4. Clearly in the area of arithmetic skills impulsive students performed better with impulsive teachers and reflective students with reflective teachers. However, in Set Language though the results were the same when matching reflective teachers to both groups of students, with impulsive teachers the standard produced by both sets of students were on a par, low.

It is apparent that results from aptitude-treatment or type-treatment studies are to be expected, although the effects of personality and motivation on attainment are likely to be less strong than those of either previous attainment, including ability level or teaching style. However, there has been little research into the effects of matching or mismatching the teaching with learning style - a variable which has more direct relevance to attainment than any measure of personality. Pask (1976) in reference to his work on such matters suggests that extreme teaching styles could be markedly disadvantageous to students with a mismatched learning style.

An important aim in education should be to help students to adopt integrated, flexible and versatile styles of learning. Similarly it must be emphasised that teachers should similarly be encouraged to be equally versatile in using a variety of methods of presentation, appropriate to the subject matter being introduced. What applies to the student who is responsible only for his own learning, applies even more strongly to the teacher who is guiding the learning of many students.

A poignant point which summarises the approach which lecturers/teachers should adopt is made by Larillard (1979):-

> 'It would be dangerous to assume that our students possess learning styles that are inherent, unalterable, and inflexible. Rather, as teachers, we should be asking whether the learning environment we create, especially in the kinds of course content we favour, the assessment demands we make on students, and the guidance on approaches to study, are such as to encourage or discourage a student in expanding his/her repertoire.'

4.4 Methods of Teaching Delivery and Assessment

Certain factors that emerge from the two major teaching strategies discussed in Sections 4.2.1 and 4.2.2 The first one is that with student-centred learning it is clearly a vehicle for an open-learning approach, this means the utilisation of a wide range of resources and in general requires colleges to have open learning style centres. Within such a framework CAL by its very nature is a natural resource amongst others for such centres. The individual college must decide whether to adopt such approaches or adopt the more traditional learning approach, which is not so accommodating to a CAL teaching environment.

The following Section 4.4.1 outlines the various methods of delivery available to the teacher/lecturer, which are applicable to each of the teaching strategies and puts into perspective the place of CAL within these. Above all they attempt to show the possibilities for a more flexible approach to managing the learning process, suggested by Section 4.3.

4.4.1 Methods of Teaching For Teacher/Institution-Centred Approach

The methods range from purely expository methods such as the lecture or talk to methods which involve a much greater degree of individualised learning or group work. All of these activities occur within an educational structure which is organised or run by the teacher/lecturer, operating within the fairly rigid constraints of the institution in which he/she works.

At the further education level, expositions in the form of lectures, films, broadcasts etc. are by far the most common teaching methods, together with private reading and other individual work, tutorials, seminars and practical work.

Lectures and Talks - Despite the plethora of other teaching methods available, the face-to-face talk or 'lecture' still holds a central position at many levels of education. It is rather surprising that comparatively little is known about the educational effectiveness of the lecture. Hence the strength with which opinions on the usefulness of lectures are held is frequently greater than the strength of the grounds upon which these opinions are based. In addition the problem of defining what constitutes a 'good lecture' is exceedingly difficult since several research studies e.g. McLeish (1968) have indicated that individual students appreciate not only different, but sometimes conflicting things in a lecture.

Practical Activities - Within most teacher/institution centred teaching systems, laboratory-type classes are a common way of demonstrating the practical elements of a subject and of 'using the theory'. The use of such practical sessions in this mode would appear to be capable of doing nothing but good; nevertheless, careful analysis of their use is often necessary if the fullest potential of such exercises is to be realised.

Film and Video Presentations - Films have been used in education as a mass-instructional teaching method in their own right for many years. With the arrival of the video-cassette recorder the practice has become even more prevalent. There are a wide range of films and video-cassette programmes now available for the further education market. As well as a teaching method in their own right they can be incorporated into lecture-type presentations in order to provide illustrative visual stimulation and variety of approach.

Educational Broadcasting - In most cases broadcast radio and television education programmes have been limited to that of general interest, 'optional extra' or back up material, in the further education sector. Although in recent years with the influence of information technology the quantity and quality of broadcasts material has greatly increased.

Audio visual Media - Chalkboards and whiteboards are widely used in all sectors of education for the display of impromptu notes and diagrams, during a lesson and for working through calculations or similar exercises in front of a class. The whiteboard has the added advantage of doubling as a projector screen. Feltboards can be used for permanent or semi-permanent displays, but their main application is in situations requiring the movement or re-arrangement of pieces i.e. in the build up of electrical or electronic type circuit arrangements. Magnetic boards fulfil a similar function.

Wallcharts can play a variety of different roles. They can be used to stimulate interest and provide motivation and act as a source of ideas or topics for discussion. Also they can be referred to at random in order to produce gradual familiarisation with their content and to act as an information store and memory substitute.

Flipcharts are best used to present visual information which supplements a verbal explanation. Models on the other hand are often used in cases where movement has to be illustrated e.g. electrical machine principle of operation.

Pre-prepared notes, diagrams and tables can be given to students in the form of hand-outs. This can save the student from tedious and perhaps inefficient notetaking allowing concentration on what is being said. However, very complete hand-out notes may encourage laziness, or even absenteeism. These are reasons why some teachers/lecturers use partial hand-outs.

Filmstrips and slides can be of great assistance to a teacher or lecturer in providing visual reinforcement to what is said and are particularly useful for showing photographs, diagrams, and other graphic material. Films also provide an important resource in filling a number of instructional roles, ranging from front-line teaching to their use for illustrate or motivational purposes. Video-cassette and Videodisc machines are now tending to replace the role of the film projector. Tape and Cassette records can be used for audio purposes in a variety of roles. Such examples are for play back of talks to a class or to provide illustrative supportive audio visual material in the context of a 'live' lecture or lesson, plus commercial audio programmes covering a wide range of subjects.

The overhead projector (OHP) is probably the most versatile visual aid that can be used to support mass-instruction methods. As a consequence its use has become extremely widespread and popular over the last 20 years. In fact it has often replaced the traditional chalkboard as the most commonly used visual aid in many schools, colleges and training establishments enabling the teacher/lecturer to present notes and diagrams and calculations in a similar fashion, but with the lecturer/teacher able to face the class all the time.

Tutorials - In group tutorials the topic(s) to be investigated or problem(s) to be solved are chosen by the teacher/ lecturer, who also usually decides how to organise the session. However, what actually happens during the tutorial depends to a large extent on the performance and concerns of the individual students in the group. They are useful vehicles for providing practice in the application, analysis and evaluation of knowledge. Often, they take the factual content of a subject and treat it at Bloom's 'high cognitive' levels. Hence it can often be used for developing skills in areas such as problem solving and critical appraisal.

The work done by the students for tutorials is prepared in many cases in the form of an essay, a project, or answers to a series of problems. In such tutorial type situations a teacher/lecturer can use the students labours to focus upon areas of common and individual difficulty and discuss easy/project report writing or problem solving techniques in more general terms.

A major drawback of such subject based tutorials is that there is often a tendency for the teacher/lecturer to become over dominant and in some cases, to use the tutorial as a 'mini-lecture'. Under such circumstances the opportunity to develop the students problems solving and critical appraisal skills may well be lost.

Seminars - The seminar technique covers a wide range of general group discussion approaches to learning. The term can have widely different connotations for people working in different subject areas and at different levels of education and training. With further education and particularly in electrical/electronic engineering it is a little used method. It is more applicable also to student-centred methodology and will be elaborated on under this strategy.

4.4.2 Methods of Teaching for Student-Centred Approach

The main teaching methods used in the great majority of student-centred courses are individualised methods of one form or another. Many of the materials associated with individualised learning are highly structured and interactive , although this is not necessarily the case. The materials may or may not have an audio-visual element, depending on the topic being covered and the specific design objectives. Typical methods are Textual Materials, Audio-Visual Self Instructional Materials, Computer Based Self Instructional Materials. Along with these methods are Talks, Seminars, Role-Play, Surveys, Simulation, Group Work/Practical Activity and Research.

Tutorial support is a vital feature of all student-centred learning systems, with the precise nature of this support being strongly dependent upon the situation and location of the individual learner. Some course may require practical work to be integrated into them. This is absolutely imperative in BTEC National and Higher National Certificate/Diploma courses in Electrical and Electronic Engineering course. This work has to be made as accessible as possible for the student, and may involve the development of individualised kits for use at home, or the provision of more organised facilities within the host institution or some other centre.

Expository methods such as lectures normally have little place in student-centred strategies. However, some student-centred courses do include a certain number of lectures, often on an optional basis, in order to provide an introductory review of a topic or for 'enrichment' purposes.

Textual Materials - Conventional text books can often be used, but by themselves are often not suitable for mastery of desired material to be achieved. Their relevance can often be improved with the use of a study guide. However, without participative student activities built in this will tend to lead to a passive form of study.

The lack of suitable text books covering the necessary objectives of a course can be offset by carefully prepared structured notes with student interaction built into them. A programmed learning approach can improve the student interaction with textual learning materials. However, they are difficult and time consuming to produce. Also used over large areas of subject material they can become boring to the student.

Audio Visual Self Instructional Materials - These help to increase the impact and effectiveness of self instructional materials. Included in these aids are audio and video tapes, film strips, loop films, slides and transparencies, models and practical kits as well as conventional printed material.

Audio Visual programmes can involve a high degree of student activity and are, in many cases, used to save tedious tutor repetition. Such programmes can be used to achieve a wide range of educational and training objectives. They may be used very effectively for helping to achieve mastery of factual (cognitive) material, in psychomotor skills training, and also in the attitudinal (affective) area.

Broadcasting media as mentioned in Section 4.2.1·plus use of videotext systems such as Prestel and Oracle along with such as the Neris database provide sources of information for subject areas. In such systems the viewer can interact with the information shown on the T.V. screen via a small keyboard and the learning sequence can be made appropriate to his/her individual needs. The usefulness of such systems will increase as the specialised material for specific courses becomes available.

Computer Based Self Instructional Materials - Computer Assisted Learning (CAL) can play a number of different roles in individualised learning schemes including front line teaching, assessment, managing resources and maintain administrative records.

Whatever the hardware used, the computer acts in the main in one of two basic roles in all CAL systems, namely a tutorial mode or in a laboratory mode or sometimes a combination of both. an a tutorial mode the student interacts directly with the computer, which is programmed to understand and react to student responses. This is basically a sophisticated style of the branching programmed learning, mentioned in Chapter 1.

In the laboratory mode, the computer is essentially a learning resource rather than a teaching device. The computer can be used to simulate a laboratory situation to model experiments, to provide databases, to set problem solving exercises and so on. For example, a student can investigate mathematical models of physical systems such as control systems and see how specific factors vary under different conditions which he/she can control. The topic of CAL is discussed in depth in Chapters 5 and 6.

Interactive Video - This is a relatively new form of media presentation utilising the use of video-recorders and compact disc players and computers in an integrated teaching resource. The marrying of these two aims to combine a flexible interactive and accessible teaching programme through the computer, with good visual and sound characteristics, through the video-recorder/compact disc player. A more detailed discussion of interactive video and its future development will be considered in Chapter 5.

Talks - In student centred learning this refers to talks given by students, especially when following a research assignment, or a survey conducted by the students, are a very useful way of involving all students. The audience can be active in assessing and evaluating the various aspects of the talk. It enables students to display competence in 'their' specialist area.

Planning delivery and self-evaluating a talk are worthwhile skills in themselves. Lecturers/Teachers can also guide and support, which is especially important when the content is at all critical.

In this methodology students are active, involved, make decisions, ask questions, evaluate, practice communication skills, and increase self confidence, also they are usually in a good position to have a large measure of control over content. However, care must be taken over supporting students prior to this type of exposure.

Seminars - This tends to be an under used activity outside of higher education. The students inquire or research into a given area and report back, usually using extensive notes, report/or essay style writing to the group on their subject. They may be assisted by the lecturer/teacher and questioned by other students. Again, with this methodology self confidence is enhanced and the students all play a part. If students can clearly explain something verbally then they probably understand it well.

Role-Play - Dramatic techniques are well known as motivators. At their best they can fully involve students more than any other activity. In role-plays only rudimentary, outline scripting occurs. The issue or situation being more important than professional acting expertise.

Students gain such skills as other person's viewpoint, social skills, communication and the full involvement with the issues behind the activity. The lecturer/teachers primary role is to set the scene, and assess performance.

Surveys - Students participating in the preparation for, execution and analysis of surveys are able to practise a wide range of skills. Amongst these are questionnaire design, data recording, judgement, numerical and summative skills, evaluation and self-critical reflection. Also students seldom abuse this type of methodology, taking it quite seriously.

Simulation - Similar to role play, but tends to be mores specific and stylised. A typical example would be a mock interview of a prospective student for a college place. This involves students thinking about criteria for selection, strategies, likely questions, and other points about interviews.

A special advantage is the extent of student involvement and the sheer breadth of discussion before during and after the activity.

Group Work/Practical Activity - Such work can enable students to learn quite clearly the nature of the interdependence of many human activities not least at work. Practical work can be introduced, as well as group work to many areas of curriculum. In fact it is an absolutely vital ingredient of all BTEC National and Higher National Certificate/Diploma courses in Electrical and Electronic Engineering. Such a methodology can be of benefit to students of all levels and abilities.

Research - Along with techniques such as survey, information finding need not be confined to books or even journal articles. Students finding addresses and telephone numbers, arranging visits, making contracts, telephoning, and writing real business letters to organisations, are all areas which involve and extend students.

With practice and encouragement even the least imaginative or least confident students will respond with enthusiasm when it is clear that staff encourage this.

4.4.3 Student Assessment Methods

The question arises with any form of learning and particularly with a student-centred approach incorporating CAL methods how do we assess the students performance and whether we in fact should? Before attempting to answer this question the various techniques of assessment should be outlined.

Student assessment methods can have a variety of forms. The most common general approach is via some form of written response, i.e. 'pencil and paper' approach. This type of approach covers a whole range of 'traditional assessment methods such as essays, short notes, questions and problems. The main difficulty with such methods apart from problems is the validity and reliability in marking is in doubt.

Another form of 'pencil and paper' approach involves the use of 'objective tests', although such tests seldom involve the student in writing very much; in most cases, a mark made beside one of a range of possible options, or a single word answer, is all that is required. The most common type of objective question is the multiple choice item, together with its range of variations. Other types of objective questions include completion items, unique answer questions, and structural communication tests. The term objective means that the questions can be marked totally reliably by anybody including a computer. Also they enable wide coverage of syllabus content. However, the major problem with such assessment methods is the difficulty of constructing the questions particularly for high level abilities. This tends to restrict such tests to the lower cognitive skills.

Practical tests are often used to assess psychomotor and manipulative skill objectives. These tests include such techniques as project assessment, laboratory examination and other skill tests designed to assess manipulative skills.

Situational assessment techniques are also in this category which involves students using non-cognitive skills such as decision making skills in a real, or more likely in a simulated environment. There are also a range of unobtrusive and observational techniques which can take place without the student necessarily being aware that they are in fact being assessed. Such tests can be important in assessing a student's commitment and attitudes to work, rather than simply his/her ability to perform tasks under the controlled conditions of more formal assessment.

Percival and Ellington (1984) summarise assessment well with the following phrase "An appropriate variety of assessment techniques should be used to match specific objectives, thus producing a practicable assessment strategy that not only has a high degree of validity and reliability, but is also fair and useful to the students.'

Clearly when we are attempting to assess student performance in a student centred learning environment the use of traditional style exams is patently unsuitable. They fail to take into account the students attitudes and commitment to the tasks set.

Situational assessment techniques and unobtrusive and observational techniques would appear to offer the best form of assessment when using student centred learning incorporating CAL, as they tend to give a better overall picture of student performance.

These techniques along with practical tests offer the best approach to assessing students in the specialist electronic and electrical subjects. This is because in industry the question asked is, 'can someone do the job', not whether they can memorise and then regurgitate.

However, at present the Mathematics and Electrical Principal Core Subjects have to have a traditional final examination as part of their overall assessment, counting for 50% of the overall grade mainly due in order to satisfy University and Polytechnic entrance requirements. The specialist subjects are assessed 100% by assignment work within my own college. Such techniques as outlined have been used and found to be in practice more satisfactory than the traditional methods in building up an overall profile of the students ability.

4.5 Comments

In the previous sections of Chapter 4 an attempt has been made to illustrate that students do not necessarily learn the same way. The reality of the situation is that they can possess widely differing learning styles. Lecturers/teachers through the particular learning styles they used as students has in general led them to adopt particular teaching strategies either a teacher-centred or student-centred approach or even a mixture of both.

The importance of matching, learning and teaching styles outlined in order to emphasise that there must be a flexible approach both by students and teachers/lecturers. This hopefully will tend to lead to teaching/learning strategies being adopted in order to ensure the student achieves maximum benefit from the learning process. The inference for CAL is that courseware should be written which attempts to cater for a wide variety of learning styles. In effect CAL becomes a 'flexible tutor'.

On examining the two main teaching strategies there are clearly advantages and disadvantages of both. The teacher centred approach has a major advantage in that it is very much the 'traditional' approach to which most further education institutions are geared to, both from a teaching and administration viewpoint. As such it tends to make efficient use of resources available within the institution. However, it also has a major disadvantage. This type of strategy tends not to cater for the individual needs of the students. By virtue of the nature of the strategy there is a tendency to aim for the 'middle ground'. This means the less able and the brighter students often suffer in terms of the effectiveness of the learning process. It is however, possible to overcome such a difficulty by the use of CAL courseware which is written to cater for different student ability levels. This type of courseware would enable the student to select the level of difficulty of the material to be presented. Another important disadvantage is that the effectiveness of this strategy depends totally on the quality of the teacher/lecturer. There is also a tendency under this strategy to encourage 'spoon feeding' and allowing little scope for individual student development. The report on the 16-19 provision by Her Majesty's Inspectorate, HMI (1984) made a very pertinent point concerning teacher directed strategies,

> '...Spoon feeding and over directive teaching are still too common and as a consequence able students may fail to reveal or discover their full potential, especially when taught in these ways in very small groups.'

In the case of the student-centred teaching strategy there are a number of important advantages. Materials are more readily available and objectives clearly spelt out. The course units are specifically designed to be student-centred with students selecting from a range of units to suit their own education needs. As outlined in Chapter 2 on curriculum, the BTEC National and Higher National Certificate courses in Electrical/Electronic Engineering the units are becoming geared towards such an approach. Albeit programmes are designed with local industrial needs in mind.

With this strategy teacher/lecturer help in counselling and guidance are generally more readily available and relevant than with the more traditional teacher centred strategy. More importantly the weaker students have the opportunity of receiving more attention. Close links between the teacher/lecturer and student ensure regular feedback on the students progress. This has implications for CAL. Obviously an important criteria for utilising it as a teaching resource must be that the student receives feedback at regular intervals continually reinforcing the learning process, if it is to be effective. A major disadvantage of the student-centred learning strategy is that it is very much dependent for its success on the students being highly committed and motivated. Also the difficulties in producing adequate resource material and teachers/lecturers acquiring new instructional skills can be considered as important disadvantages.

These disadvantages are also applicable to CAL in that production of quality courseware is time consuming. Teachers/lecturers often either through lack of interest or funding for suitable training are inadequately equipped to select, use and develop CAL type resources. It is most important also that CAL should possess high motivational qualities.

Vital to the successful implementation of a student-centred teaching strategy is the administrative system geared to support it. Clearly one could continue to argue the case for and against student-centred learning. However in considering its worthwhileness one might do well to reflect on the following quotes:-

Rogers (1965) states:-

'I know I cannot teach anyone anything, I can only provide an environment in which he/she can learn.'

Postman and Weingartner (1969) state:-

'Good learners seem to know what is relevant to their survival and what is not. They are apt to resent being told that something is good for them to know.'

Ausubel (1968) implies that:-

'The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him/her accordingly.'

Ilich (1971) says that:-

'In fact learning is the human activity which least needs manipulation by others. Most learning is not the result of instruction. It is rather the result of unhampered participation in a meaningful setting. Most people learn best by being 'with it', yet school makes them identify their personal cognitive growth with elaborate planning and manipulation.'

All of the above quotes would appear to strengthen the case for the use of student-centred learning particularly those of Rogers (1965) and Ilich (1971). They also have connotations for CAL in that it can be designed to create the environment in which effective learning can take place removing the tight constraints placed on students by the more traditional teaching methods.

Bennett(1976) contrasted the two different teaching strategies in a very positive way as shown in Figure 4.6, Appendix 4. This acts to summarise the main ideals of the two strategies.

An examination of the various teaching methodologies under the two strategies was carried out in order to highlight the significance of both traditional CAL and Interactive Video in the scheme of things. It can be seen that it offers great potential as a teaching resource within the student-centred learning strategy. Since this appears to be the direction that BTEC National and Higher National Certificate/Diploma programmes are going, then the need for good resources that compliment this strategy are of paramount importance. The climate is undoubtedly ripe for CAL as a major resource to flourish, particularly with the steady increase in popularity of open learning systems.

CHAPTER 5

COMPUTER ASSISTED LEARNING (CAL)

5.1 General

The use of computers in education and training has been greatly influenced by the history of their introduction into universities, colleges and industry and by their use in applications other than education and training.

First in North America and then in Europe and elsewhere, teachers/lecturers have realised that the power of the computer as a machine for storing, organising and processing information can be applied to teaching and learning. The computer may be used as a classroom resource, as a calculator, as a model of some real-life situation or as a means of producing animated visual aids.

Alternatively it may be used in the background to help with the classroom management, keeping records of the student's performance and carrying out other supportive functions.

In industry and commerce, the original reasons for installing, computers were to support the everyday processes of the organisations; to carry out the calculations for payroll and invoicing, to process stock control information, to model the financial behaviour of the company and its environment, to control production lines and processes, and recently for more sophisticated applications such as airline reservation and operating systems. As teachers/lecturers came to realise that computers could be used to support their teaching, so their colleagues in industrial training saw that the computers already in their organisations could be used to help in the training process.

Whether in education or training, teachers and lecturers are faced with many and varied problems relating to their teaching and their students' learning as highlighted in the previous section on teaching and learning styles.

Highly structured courses such as the BTEC in Electrical/Electronic Engineering to meet the particular needs of individual students pose problems of instruction; modular course structures with more sophisticated assessment methods pose problems of student management; student centred courses to meet the particular needs of individual students pose problems of resource management; necessary practical experience may be time consuming, expensive, or impossibly dangerous. Educational technology in its widest sense, provides teachers and lecturers with methods and tools which, properly applied can alleviate some to these problems. The computer used as a learning vehicle in the form of CAL is one of these tools.

5.2 CAL Definitions

The development of computer assisted learning materials is prey to a variety of misconceptions, from the assumption that its all about teaching about computers to the idea that such development is, in essence a factory-line production of software. This is largely a result of a lack of clarity about What Computer Assisted Learning is, or can be.

Any attempt to define Computer Assisted Learning (CAL) is fraught with interesting problems. A perusal of the literature if the seventies finds much confusion between Computer Aided Instruction (CAI) and Computer Assisted Learning (CAL). This is because the literature leaned heavily upon the America experience where the term, CAL was the norm. Such dependence on the term CAI caused confusion. Early work in educational computing often followed the 'programmed learning' path of the sixties - thus the instruction did not then, necessarily, relate to teaching and learning but rather to a highly defined tutorial path. In its classic CAI form, the computer presents the student with a piece of text which is followed by one or more questions. These are usually of the multiple-choice type. Depending on the response, the student is routed to a second frame of text and questions, or to the same questions which are repeated, or to another series of related questions. This has been referred to as 'tutorial CAL', for the sequence of texts is selected according to the performance of the student. In 'drill and practice' CAL the student is not often offered the luxury of alternative questions. He/she is routed around the same loop until they respond correctly; they are then moved on to the next section.

For this style of operation the use of the term CAL is quite appropriate, however, it is simply not synonymous with CAL. Maddison (1983) states there are clear differences between instruction and learning; CAL refers to using the computer as a learning resource to assist students in the totality of their tasks. Rushby (1979) and others e.g. Fothergill (1981) also refer to Computer Based Learning, and even Computer Based Education, but it is not apparent how either CAL or CBE can be distinguished from, or are subsets of CAL. It is more obvious how CAI, particularly as personified in drill and practice programs could be considered a subset of CAL.

Computer Managed Learning (CML) is clearly a distinct and separate area, that of using the computer to manage the learning sequence. The computer can define the students task, identify appropriate teaching materials (that may or may not, be computer based), mark the work, record the results, issue reports and assess, in the light of this performance, the next appropriate task. Nash and Ball (1982) state that:-

'whole courses can be derived in this manner.'

Maddison (1983) refers to CML for:-

'administering the business of education in all aspects.'

This would appear to be somewhat sweeping, but does emphasise the fact that CML delivers a system designed in the way that the teacher might ideally wish to manage the learning. Like CAL, it too is designed for use by an individual student. In order to provide a general overview of the definition of CAL a summarised version is shown in Figure 5.1., Appendix 5.

5.3 The Computer as a Teaching/Learning Resource

Barker (1979;1984) implies that:-

'as a teaching resource the computer can offer a number of interesting possibilities.'

For example it is able to provide:

1. sound effects and analysis.
2. static and dynamic imagery through computer graphics.
3. text handling facilities.
4. control of external devices and learning progress.
5. a variety of data capture techniques.
6. facilities for data archiva, retrieval and dissemination.
7. a means of achieving highly individualised instruction.

8. a highly interactive learning environment, and
9. facilities for pattern matching computation and decision making.

Together these basic facilities provide a wealth of resources from which to construct instructional material. When using the computer as a teaching resource two basic modes of usage are involved; author mode and learner mode. These are depicted in Figure 5.2, Appendix 5.

In author mode the computer is used as an aid to prepare the courseware that is to contain the instructional material and which embodies the authors required teaching strategies. Two basic approaches can be used for the acquisition of courseware. Either, a special package is 'bought in' or the teacher/author produces it. In the former case, ready-made packages often have to be modified to meet local needs. Where it is applicable, this can provide a cost effective approach. However, in situations where the teacher/lecturer has to generate the courseware from scratch, some form of programming has to be undertaken- this could mean higher costs. The production of courseware with this latter technique is achieved either by using a programming language such as BASIC or PASCAL or by means of a special author language such as PILOT, MICROTEXT, TOP CLASS etc. An author language is a special high level tool that is specifically designed to facilitate the preparation of instruction software. These techniques for courseware development will be examined in a later subsection.

Once the courseware has been developed, it is loaded into the computer where it then controls the student's interactive learning environment. This is now called the learner mode. In this mode, the computer presents instructional material (sound graphics text etc.) to the student and monitors the responses produced. These are then used to determine the subsequent direction that the course of instruction will take. During learner mode, all student responses can be archived and subsequently analysed by the computer. The results of the analysis can be passed back to the author/teacher thereby providing valuable feedback on student progress and courseware performance.

As a teaching resource the computer has a valuable role to play in education and training.

Watson (1987) refers to the computer as a learning resource as being:-

> 'an area which embraces the way the computer assists learning in a variety of ways according to the design of the software'.

CAL therefore can be distinguished from use in research or administration of teaching about computers or from using the computers to manage learning, because the others are external uses of, or teaching about computers. CAL means learning with the assistance of the computer itself.

This is not to say that CAL does not sometimes embrace aspects of these other four. Hooper (1975) who provided a classification of five uses of the computer in education, namely in research, the teaching of computing, administration, management of learning, and as a learning resource, states that terms such as CAL and CML cannot have watertight definitions. Students in further education studying a subject such as Industry and Society as part of the BTEC National Certificate/Diploma courses in Electrical and Electronic Engineering may embark on research using computers when seeking out data from local archives, encoding and interrogating it as part of an assignment in such as local regional policy for industry. In other subject areas they may word-processing packages as part of their assignment work - though they will be using them for administrative reasons, they will also be using them as an aid in developing their communication skills in the written context. Computers may be used in the technical subjects of analogue and digital electronics and power control subjects in the BTEC National and Higher National Certificate programmes to control and manage experiments which form part of the technological subject lesson.

Computer awareness for the students will be achieved most naturally if they are educated in establishments that do not necessarily run computer awareness courses, but which openly and clearly use computers wherever appropriate. The one which may have greatest impact, because it should reach the students in a variety of forms through different disciplines is CAL.

5.4 Scope of CAL

Computer assisted learning and computer assisted instruction may be thought of as domains that encompass any activity in which a computer is used to augment (or initiate) a learning or training process. In this context there are two fundamental approaches to the use of computer systems. There are those applications in which:-

1. The computer itself is not only the medium of instruction, but is also the subject of instruction, information technology, microelectronics and general computer literacy are all high on the agenda in BTEC National and Higher National Certificate courses in Electrical and Electronic Engineering in most colleges.

2. The computer just acts as one of the many media that are used in the teaching of some other discipline such as could be used in Mathematics, Engineering Applications of Computers, Electronics NII and NIII, Electrical Applications NII and NIII, Analogue and Digital H and a host of other subjects.

Barker and Yeates (1985) infer that:-

'no matter what the subject that is taught, the objectives of CAL remain the same.'

It is intended to be used as a means of:-

1. augmenting conventional teaching/training methods.
2. accelerating the learning process.
3. experimenting in course development.
4. providing remedial instruction.
5. providing individualised instruction.
6. providing enrichment material.
7. achieving consistently higher teaching/lecturer standards.
8. providing cost effective instruction.
9. providing 'on-demand' instruction.

Coffey (1978) refers to the last of these as being :-

'particularly relevant to the the implementation of Open Learning Systems (described in previous chapter) in which students can gain access to instructional material as and when they need it, no matter where they are geographically located.'

The use of computer communications networks will be of significant importance in promoting this type of learning environment on a nation-wide scale.

The scope of CAL includes a wide variety of instructional functions. These have to be realised in terms of a limited number of CAL modes. The CAL functions to be performed and a selection of the CAL modes available for their implementation are listed in Figure 5.3, Appendix 5.

Each of these functions and modes is applicable to all levels of education and training. The above modes need to be dealt with in some detail in later sections.

The scope of CAL application areas is probably as diverse as the number of subject areas in which it has been employed. For this reason it will be beneficial to attempt to classify applications of CAL into four broad categories, namely schools, colleges, industry and the home. Since we are looking at CAL within the further education sector this area will be examined in more detail.

?5.4.1 CAL in Further Education

In principle the use of CAL in further education is controlled by similar objectives to those that govern its use in schools such as providing an effective teaching aid and learning vehicle, enabling all students/pupils to learn at a pace suitable to themselves. However, the complexity of the domain orientated material that is used is likely to be much greater. Because of this the type of hardware employed and the nature of the courseware that drives it, is likely to be much more sophisticated than its counterpart at school level. This is particular so with respect to the teaching of electrical and electronic engineering skills using CAL. There is a basic requirement in this area for very high quality software that is able to generate realistic and effective instructional dialogues. Undoubtedly, this objective will only be achieved by building a high degree of 'intelligence' into the software used for teaching at this level.

When planning for the CAL requirements of further education there are at least three important factors that need to be taken into consideration. First of all, it is important to bear in mind the educational maturity of students in colleges particularly those attending part-time day release and evening courses such as the BTEC National and Higher National Certificate. Students in these categories are able to study on their own and require far less personal attention from lecturers than do learners in a school environment.

The second important factor relates to how courses meet student requirements. Students in further and higher education prefer to select combinations of courses which are able to meet the requirements posed by their intended career pathways. The BTEC type courses are all module based allowing a variety of modules to be combined to form a suitable course i.e. different modules and subject objectives can be put together to form a BTEC Ordinary National or Higher National Certificate in Electronics to suit the requirements of students employed in the local industries. Quite often, in conventional class-room orientated teaching environments time-tabling clashes can preclude certain important combinations of options, unless they are taught on an un time-tabled self-study basis. The third factor to be considered is the teaching of minority interest subjects. Because of the availability of staff many useful courses in this category fail to run. This situation often arises either because (1), it is not cost effective or (2), a staff member who is capable of teaching it has to be time-tabled for other duties.

Each of the types of problem outlined above can be solved in an effective way through the use of appropriately designed open learning systems. CAL can play an important role in this type of approach to education as indeed it can in helping to solve directly some of the problems highlighted above.

5.4.2 Approaches to CAL

In terms of providing a CAL facility three basic types of computational resource can be employed: a mainframe system, a minicomputer system and/or a microcomputer system. These may be used to support courseware packages that are bought in as such and then modified to meet local requirements or produced in-house using either a programming language or an authoring system as shown in Figure 5.2, Appendix 5. The software and its accompanying hardware, must motivate the student in a positive way. That is, it should encourage the student to learn about and explore the universe of discourse with which it deals.

One of the most useful rules to remember when using CAL is: monitor and modify. As Barker and Yeates (1985) suggest:-

'always attempt to monitor the performance of courseware. Then if need be, modify it in the light of experience in order to optimise its performance. Performance can be measured in terms of student satisfaction and attainment.'

High ratings in these metrics are the hallmark of quality software.

5.5 Models of CAL

5.5.1 Classification of CAL Resources

In attempting to relate theories of learning to CAL one must categorise the types of software available. Kemmis, Atkin and Wright (1977) and also Howe and DuBoulay (1979) proposed a framework for computer assisted learning. They described four paradigms for applying the computer to education and within these are encompassed the various classifications for CAL software. The model is shown below in Figure 5.4, Appendix 5.

Instructional programs are available for many topics and for a wide age range. The demonstration type in which the user's only action may be to start, branch, or stop the program, can only be really justified in comparison with a good textbook if it does something which a textbook cannot such as demonstrating dynamic behaviour like the movement of an electron beam in an oscilloscope when subjected to an applied input voltage. Both drill and practice and the programmed learning modes (tutorial type programs) are basically designed for individualised instruction. As they require constant user feedback for evaluation of learner progress, they will normally only be efficient with one micro per student. The aim of many educational games is simply to provide drill and practice by introducing motivational material and competition. They can frequently be used successfully with more than one student per microcomputer. Games can be associated with simulations and problem solving i.e. classified in revelatory paradigm.

In the Revelatory paradigm case studies require considerable time and expertise to produce, usually requiring additional non-microcomputer educational material, and may have a limited market as reflected by their cost. Normally for use with students in the further education sector and the old school pupils, and can be structured for use with groups. A simulation is different from a case study in that it concentrates on certain elements relating to a real situation while ignoring others. This usually allows the whole of the information relating to the simulation to be contained within the computer program.

Exploratory "programs" include those with an external goal (problem-solving), and those in which the user is given a basic minimum of ground rules and allowed to create anything desired within those rules. The later may be a "programming language" such as LOGO, PASCAL, ASSEMBLER, OR C. the main characteristic of this group of programs is that the users must devise their own procedures and may set their own objectives although guidance form teachers/lecturers in the form of worksheets may be desirable in the preliminary stages. If a language framework is used, the greater its flexibility and complexity the more the user must use problem-solving skills to achieve their goal.

Emancipatory type programs involve using the computer as a labour saving device, a tool which relieves mental drudgery see examples in Figures 5.4 and 5.5, Appendix 5. In this type of CAL the learner uses the computer as and when he wants to as an unintelligent tedium relieving slave in aiding his or her learning process and takes over the "inauthentic" part of the learning task, (not an integral part of the main learning task (authentic task)). Some programs may contain elements of two or more of the above categories.

Wellington (1985) effectively extended the framework developed by Kemmis and others by combining the educational paradigms with the control exercised by the computer and learner as shown in Figure 5.5, Appendix 5. Chandler (1984) had provided a set of extremely descriptive categories which he referred to as models. However, there is a similarity to the work of Wellington in that he refers to a locus of control which he refers to as moving between program and User.

Armstrong, Wiseman and Bajpai (1989) extend the idea of controlling influences which exist in a CAL situation in their model to promote flexibility in the development of effective CAL for mathematics. However, the model has significances for all areas of technology. In developing such a model of a real work situation the dynamics of the situation are suppressed, but not forgotten. The roles which exercise control in a CAL situation are the Learner, the Teacher, the Computer and the Environment.

The proportions of Control are designated as L for learner control, T for teacher control, C for computer control and E for environment control. This may be represented mathematically as $L + T + C + E = 1$

If the environment is assumed constant, which is feasible in many situations then $L + T + C = K (1 - E)$. This can then be represented graphically in Figure 5.6, Appendix 5.

Maddison (1983) criticised the educational paradigms of Kemmis, arguing that it places too much emphasis on instructional methods and that its formation of the conjectural processes is weak. By incorporating these paradigms onto the model of Figure 5.6, Appendix 5 a graphical representation as in Figure 5.7, Appendix 5 is achieved. This reveals a further possible limitation to the Kemmis model which Armstrong et al remedied by the inclusion of the electronic blackboard to cover the situations where the teacher/lecturer uses the computer as a 'demonstration aid', as opposed to the use of the computer for individualised learning. The model can be extended to illustrate the teaching strategies and learning types discussed in Chapter 4 as shown in Figure 5.8, Appendix 5.

Although this is not referring directly to CAL, Johnson and Johnson (1985) point out that:-

> 'co-operative learning groups roles should be rapidly and continuously changing and that the discussion between pupils/students working with computers in such groups is important.'

This will demand a descriptive model far more dynamic than static classifications allow. The aim of this model being to outline the dynamic nature of CAL and to ask relevant questions concerning its use in the classrooms and this aim closely relates to the teaching/learning strategies depicted by Figure 5.8, Appendix 5. Since it must be stated that when computers are to be used in the mathematics or technology type subjects like electronics and microcomputing, the parties involved carry an important responsibility for apportioning appropriate control.

A new non-real axis can be added to the model to extend its usefulness, and arguably is the most important since it refers to the learning which takes place as a result of CAL.

This axis can be described in terms of cognitive theory. The work of Ausubel (1978) described in Chapter 3 and his model of Figure 3.5 Appendix 3 suggest one possible form for the additional axis in considering a continuous variation in the learning process, from 'rote' to 'meaningful learning'. Other parallel cognitive learning theories to Ausubel's referring to a continuous variation in the learning process are, The Cockcroft Report, Mathematics Counts (DES 1982) which reflects these theories by distinguishing 'fluent performance' based on rote. Also Skemp (1971) refers to' relational understanding' (whereby a learner knows how to tackle particular cases and also knows how to relate the procedures involved to more general mathematical situations), as distinguished from instrumental understanding' (rote memorising of rules for particular classes without knowing why they work).

Armstrong et al chose an axis describing a continuum from rote to understanding to illustrate how the model could be used to construct 'descriptive profiles' of different CAL modes as shown in Figure 5.9, Appendix 5.

The profile is intended as a means to promote relevant questions not as a mathematical means of defining learning as a function of teacher, learner and computer control. However, as a relationship is suggested by the model 'clouded' regions are shown to indicate probability rather than fact. A problem remains with the model of identifying the type of learning which has taken place. The profile of

Figure 5.9, Appendix 5 was constructed selectively, on limited evidence, since suitable research findings are at the moment, rather sparse or unsuitable. Scientific research due to the number of variables associated with the human learner would preclude the use of control groups etc. Alderson and Blakely (1986) imply that questionnaires and diaries have more relevance, but there is some doubt whether they reveal what is actually happening in the classroom. The directions of research in this area should lean towards observation and interpretative techniques as used by Hoyles and Sutherland (1987) in the LOGO Maths Project. Methods of date collection should be via conversations with software users i.e. teachers and students and by observing classroom practice, in order to interpret such as;

how control was apportioned

the mode of use

the degree of understanding

the motivational value

Further changes in the non-real axis can evoke more pertinent questions relevant to CAL. Figure 5.10, Appendix 5 illustrates a variation using a non real axis of motivation. This may be described in several ways. Day and Berlyne (1971) identified it as a variation of cognitive processing from 'perceptual curiosity' in which sensory novelty stimulates perceptual attention (for example CAL software employing colour, animation etc.) through 'epistemic curiosity', stimulated by incongruity, ambiguity or novelty; to 'epistemic exploration' (knowledge-seeking through observation, consultation and directed thinking or problem-solving). Such profiles would raise many important questions for CAL design and use. Armstrong et al (1989) feel:-

> 'it supports their plea for flexibility suggesting that the affective levels of learners will not be raised by concentrating on a single CAL mode.'

A final axis which is made reference to, relates to mathematical competence. However, the axis could just as easily be making reference to competence in the electronic and electrical subjects of courses such as BTEC National and Higher National Certificate. The actual model is shown in Figure 5.11, Appendix 5. Clearly the model prompts questions about the conjectural mode which Figure 5.9, Appendix 5 possibly does not suggest. Notably does the learner need facts and skills before building conceptual structures and developing appreciation and general strategies? What does it mean for content free CAL?

Papert (1980) however, offers some possible answers to the above questions. In discussion of his 'interventionist perspective' he claims that he differs from Piaget in that his goals are education, not just understanding' and emphasises 'intellectual structures which could develop as opposed to those that actually at present do develop in the child.

As a final point relative to the above model, Figure 5.11, Appendix 5, suggests that the role of the electronic blackboard may be wider than is often realised. The suggestion is there also that software designed for flexibility and for use in several modes would have much to offer.

5.5.2 Application of Learning Models to CAL

In Chapter 3 various learning models regarded as being relevant to computer assisted learning development were discussed. These are now examined in some detail.

5.5.2.1 The Computer Model

This appears to form the basis from which a large number of cognitivists have built their theories. The important concept of executive control process being used in some of them. This process controls cognitive strategies relevant to learning and remembering in relation to such important activities as controlling attention, encoding of incoming information and retrieval of stored data. Mills (1985) implies that the rationale behind the development of educationally useful demonstration programs is based on the computer model of learning behaviour where the learner is assumed to be able to deal with only one input 'channel' at a time and only able to process information sequentially.

5.5.2.2 The Skill Model

This model provides useful guidance to devising programs for learning simple skills from discrimination between shapes and symbols to spelling and arithmetic. A microcomputer can provide a Skinnerian reinforcement in many ways ranging from a simple tick to colourful graphics or tunes. A typical example is an educational program on digital logic where part of the program involves recognising logic symbols and a suitable reply is given by the computer on screen in response to the input of the symbol name. Skinner's theory would predict that the learner's responsiveness to recognition of symbols would increase after working through this section of program.

In the case of drill and practice programs a good example is the Ohms Law Program from the 'DC' software by Garland. The computer randomly generates problems on the calculation of current, voltage and resistance to provide drill and practice in solution of Ohms Law problems. Positive reinforcement is provided by 'Well done prompts' and a regular display of the students progress with complimentary comments for good progress. On the negative or punishment side each time a student gives an incorrect answer he/she is allowed to try again and if incorrect answer is displayed. The regular display of progress highlights students poor performance with appropriate remedial comments.

Skinners work in developing programmed learning sequences is directly applicable to the design of CAL tutorial modules as shown in Figure 5.12, Appendix 5.

His views concerning the role of the teacher in the learning situation have been fully developed and moulded in a number of recent computer programs by researchers in artificial intelligence.

5.5.2.3 Hierarchy Model

This model is particularly applicable to programmed learning sequences in which the learned material is composed mainly of discrimination, concept formation and principles. The main point being is that where the type of learning required in a frame is correctly identified, the test question to which the user responds should test that type of understanding. Some of the very early teaching programs failed to do this. The testing of the learner does not have to be in exactly the same mode as the material. For example, in ensuring that such active responses to tutorial programs are relevant to the learning material, it is quite legitimate to use a discrimination test for understanding concepts or rules. The basic principle in testing is always to try to obtain a response which clearly distinguishes between learners with a full understanding and those with only partial or no understanding.

Gagne's most significant contribution to CAL has been his application of cognitive learning theory to the task of designing CAL modules in the field of both drill and practice and tutorial based software. Figure 5.13, Appendix 5, illustrates the procedure for a tutorial sequence. His concern with gaining a student's attention and developing expectancies represent a definite shift towards the motivational aspects of CAL courseware which must be of prime importance in any learning situation.

5.5.2.4 Framework Model

This model has implications for all levels of learning, but particularly for the age range up to 12. It implies that learning will be enhanced if a teaching program can start from a framework of knowledge with which the learner is already familiar. This can be enlarged by first reminding the learner of the existing knowledge then showing parallels between this and some new material and finally emphasising the differences between the new and the old.

A major use of this has been the development of LOGO and its use as envisaged by Papert (1980), which owes much in its origin to the influence of Piaget an influence can also be found in other areas such as artificial intelligence Boden (1981). These influences tend to draw on Piaget's view of children as epistemologists rather than on his cognitive outline of stages. This led to Paper to put the emphasis on 'discovery learning' via the medium of the microcomputer. Goldenberg (1982) has defined these as a:-

> 'well defined, but limiting environment where interesting things happen and in which important ideas are learned.'

These are analogous to Papert's 'powerful ideas' which are essentially cognitive skills valued by society. He emphasises mathematical and physical concepts via the programming medium of LOGO and use of the 'LOGO TURTLE'. Other followers of LOGO, like Harvey emphasise problem solving and Lawler acquisition of reading skills.

Although LOGO can be adapted for use in may ways, many of its proponents would maintain that 'pure' LOGO requires a commitment to exploratory learning and allows the user to impose their own structure on the environment. Indeed it can be argued that such an imposition of one's will upon the environment is a major component of normal cognitive growth. It is one of the few computer-based learning tools which claims a theoretical basis, and for which major cognitive claims have been made. However, it must be stated that many of these claims have yet to be substantiated by sound objective data.

Prolog is another vogue language for which similar arguments have been made. However, where it is claimed LOGO improves problem solving strategies, Prolog enhances logical thinking, and text based rather than in LOGO's case a graphical environment. Although Prolog's 'front end' has been criticised children of 9 years old have rapidly gained facility with its syntax. Further to nullify the criticisms the 'SIMPLE' front end and the 'Man in the Street Interface' (MITSI) (currently being developed) by Briggs (1984) have been developed. Its introduction in the classroom has led to a relationship to 'world knowledge' via databases on material familiar to users e./g. football facts, friendship patterns, bus routes etc. More specifically Prolog programs on digital circuit analysis and fault finding on electronic circuits have been developed.

Another example of this approach is a computer program written by Mills (1985) in which the learner is assumed to already be familiar with both the obtaining of areas of a rectangle and the use of an alphabetical symbol (say x) for representing a number. These are used to introduce the programmed learning of the multiplication of two sets of algerbraic expressions such as (5x-2y) by (x+7y).

Schenk's work is still at a relatively stage but is has already affected the thinking behind the development of expert systems.

Bandura's social learning theory seems most appropriate for the type of learning occurring in many CAL simulations. Such programmes appear to be favoured in the further education environment particularly in the areas of electronics where programs simulating robots, control systems, analogue type operational amplifier circuit simulation and digital circuit simulation and microprocessor operation. All area which are incorporated in BTEC Electrical and Electronic Engineering programmes.

The computer provides a real situation through which the student may learn vicariously through interaction with the model. Several observations seem appropriate to application of the above theory. The first relates to the importance of instructions to students to guide the learning. Secondly simulations should include as much interaction between students and the computer as possible. From a motivational point of view the computer should provide a mode that is as human like as possible. Finally the way in which lectures/teachers discuss the use, and importance of it and the physical surroundings in which it is used with affect, in either a positive or negative way, the outcome of the modelled learning. There has been a growing acceptance of a potential role for computer based simulations and Adventure games which can be classified in the exploratory style of program. A number of typical areas for such programs have been indicated above. They enable the user to adapt different strategies by experiencing strategies by experiencing a set of problems and seeing the consequences of these strategies. In doing this the learner is hypothesising and reflecting internal schemata, and allowing exploration of the implications of these schemata.

The most significant contribution of the social learning theory is that it draws attention to the importance of high level complex learning and provides guidance in understanding such learning so that it may be modelled on the computer. Advances in hardware, software, as well as in the field of Artificial Intelligence may permit the widespread application of social learning theory to CAL in the near future.

5.5.2.5 The Feedback Model

The areas of learning where this model may have practical value are more limited than the models discussed above. Sensori-motor learning involving negative feedback will be required in many arcade-type games but in very few educational games.

In the cognitive area, an understanding of feedback processes may be acquired in both simulations and exploratory programs. One example of the latter is the use of the 'turtle' in LOGO by pupils attempting to draw objects such as circles by trial and error. More specifically to the BTEC programs within electrical and electronic engineering, use is made in the subject of Engineering Applications of Computers use is made of a pneumatic sequence and bead sorter units with associated software. These units allow the sequence and sorter pattern to be varied by the student altering the control parameters that are inputted to the computer. This is very much a case of the student adjusting parameters until the required sequence or pattern is achieved. This could well be the future direction for CAL software where the physical devices are incorporated with the software package to create a more realistic environment for learning.

5.5.2.6 Ausubel's Model

This has been discussed in section 5.5.1 in relation to the profiles model of Armstrong et al.

5.5.3 Comparison of Effectiveness of Learning Models with Profile Model

It is obvious from the discussions above that in most cases it would appear that the learning theories have been associated with CAL resources rather than actually being used to design the original software. A substantial number of microcomputer programs with educational aims are now appearing in substantial numbers of variable quality which can be evaluated with reasonable accuracy by experienced teachers/lecturers. Their educational value is much more difficult to assess for several reasons, difficulties in assessing what has really been learned. Adapting the most appropriate learning style for a particular age ability. Variations in the pre-knowledge of program users.
Variations in the educational environment in which a program may be used. Uncertainty about whether any learning taking place is more cost effective than other modes of learning.

The profile model discussed in section 5.5.1 with its variable third non-real axis a flexible tool to not only take into account software evaluation, but assessing its educational value. This should if used allow software designers to produce more flexible types of software and to 'fine tune' developed software into a more usable form.

The success of LOGO which can be said to have been developed from cognitive theories in terms of its application offers us a pointer to the future development and success of educational CAL resources. Whilst psychology is a far from exact science, the learning models available to us offer some insight into the planning of teaching and learning strategies including computer based systems (CAL). Enough evidence is available from the above discussion and the work of artificial intelligence systems to indicate that future research must encompass psychological learning theories as well as the general computing aspects in order to make the best use of the new technology. The way in which we use it and design the learning experiences may well have significant influences on the expression of intellectual skills.

5.6 Types of CAL

For computer assisted learning to be effective it is necessary that the following four phases be present according to Alessi and Trollip (1985):

1) Presenting Information.
2) Guiding the student.
3) Practising.
4) Assessing student learning.

Presenting Information - The first three phases are based upon research on classroom instruction see Roshine (1983); Roshine and Stevens in press: To teach something new the teacher/lecturer must first present information, using typical methods as outlined in Chapter 4.

Not all models of teaching begin with the presentation of information however. Some models are based on the assumption that students should discover principles or develop skills through experimentation and practice as outlined by the student centred learning approach described in Chapter 4. Although such models have value for some students, Alessi et al regard one that begins with the presentation of information as more efficient and demonstrably more successful as outlined by Koran (1971); Merrill (1974); Lausmeier and Feldman (1975).

Guiding the student - The first phase, presenting information, is teacher-centred. That is, the teacher does something and the student observes. The second phase, guiding the student, is very interactive. Having observed the presentation, the student must now do something, with guidance from the lecturer/teacher. Again this means different things depending on the nature of the material. The student may answer questions about factual information, may apply rules and principles in problem-solving activities, or practice procedural skills. In each case, the teacher observes the student and corrects any errors. If the student distorts factual information, the teacher/lecturer should remind the student of the correct information, perhaps by repeating it. When the student performs a skill incorrectly, the lecturer/teacher may model the procedure or part of it again.

In the classroom, guidance often takes the form of the lecturer/teacher asking questions that students must answer. When a question is answered incorrectly, the lecturer/teacher may either tell the student the correct answer or may ask leading questions to help the student recall the correct information.

When the student learns from a book, questions or suggested activities are sometimes included as guidance. However, unlike the classroom, if the student does not perform correctly, true guidance does not occur. The student may receive help only at some time later, when the lecturer/teacher looks at what the student has done and provides feedback.

Guidance is important in teaching because no student learns all that is taught on a single exposure. Students will make errors and frequently be unaware that they have made them . It is necessary that the students be made aware of these and correct them. The interactive process of the student attempting to apply new knowledge, the teacher/lecturer correcting and guiding, and the student making further attempts is frequently omitted in teaching and yet is probably the most important component.

Practice - The teaching process is not complete when the student can do something once. The student must usually be able to perform quickly or fluently, sometimes under conditions of distraction, with few or no errors. Further more, we usually want the student to learn information permanently rather then for a short duration. Practising a skill a single time or answering a single question will not guarantee retention. Repeated practice is required for a student to retain information and to become fluent with it.

The third phase, practice, is student centred. Although the teacher observes the student and makes corrections when errors are observed, the emphasis is on the student practising and the teacher making only a short corrective statement.

Fluency and speed are related, but slightly different aspects of well learned information. To be fluent in a skill not only means doing it quickly, but also doing it without thinking about it. Mathematical skills and electrical/electronic skills such as wiring up circuits and soldering are almost worthless if not performed quickly and fluently.

On the other hand some information does not require speed or fluency. It does not matter whether one can perform an electronics experiment/investigation quickly. It is more important that such things be done carefully and correctly. However, the student should remember how to do these things. Practice not only enhances speed and fluency but retention.

Assessing Student Learning - The first three phases examined above are what most people would regard as teaching. However, we should not assume that teaching will be successful for all students. Rather, student learning should be assessed usually through the use of tests, which are an important part of the teaching/learning process. Tests provide information about the level of learning, the quality of teaching, and future learning needs. Teachers/lecturers and students alike place undue emphasis on tests as a means of assigning grades. They should be as a means of guiding learning, to determine what teaching is needed for which students, et al Chapter 4 matching teaching and learning styles.

5.6 CAL Program Types

The model described above has primarily been related to classroom teaching, but as indicated in the introduction to chapter 5 can also be applied to computer assisted learning. However, this is not to say the computer must always fulfil all the phases of teaching. Computers are but one element of the learning environment, along with lecturers/teachers and other resources. Thus, the computer may serve any combination of the four phases. It may present initial information, after which the student receives guidance from a teacher and practises using set examples. The student may learn initial information from a lecture after which the computer is used to practise some parts of the material to fluency. The computer may be used for the first three phases, with testing being done in the traditional way by the teacher/lecturer. In all cases the four parts of teaching should be present, although they may be embodied in any combination of different resources.

When the computer is responsible for total teaching, it is important that all four phases be included. it is not atypical for computer programs intended for practise (drills) to be expected to carry the load of total teaching. When this is done, students may fail to learn what is desired.

There are five major types of CAL programmes as indicated by the Kemmis et al paradigm in Section 5.1.

1) Tutorials

2) Drills

3) Simulations

4) Games

5) Tests

5.6.1 Tutorials

Tutorial lessons are computer programs that teach by carrying out a dialogue with the student. They present information, ask the student questions, and make decisions based on the student's comprehension whether to move on to new information or to engage in review and remediation. Tutorial instruction is, in a sense, the most basic form of CAL.

In general this type of program engages in the first two phases of teaching. They take the role of the teacher/lecturer by presenting information and guiding the learner in initial acquisition, not usually engaging in extended practice or assessment of learning. Some tutorials do not even guide the student through the information, but only present it. However, a good tutorial should include both presentation and guidance, while extended practice and assessment are the domain of other methodologies.

Tutorials are used in most subject areas, typical examples of such programs are the "D.C." suite of programs including Ohms Law and Resistors in Series and Parallel.

These are suitable for First Certificate/Diploma courses in BTEC Electrical/Electronic Engineering are good examples of this type of program. They are appropriate for presenting factual information, for learning rules and principles, or for learning problem-solving strategies see Gagne, Wager and Rojas (1981).

Figure 5.14, Appendix 5 shows the structure and sequence of a tutorial. It begins with an introductory section that informs the student of the purpose and nature of the lesson. After that a cycle begins. Information is presented and elaborated. A question is asked that the student must answer. The program judges the response to assess student comprehension, and the student is given feedback to improve comprehension and future performance. At the end of each iteration, the program makes a sequencing decision to determine what information should be treated during the next iteration.

The cycle continues until the lesson is terminated by either the student or the program. At that point, which we call the closing, there may be a summary and closing remarks.

Not all tutorials engage in all these activities. However, for an effective tutorial all of the components indicted in Figure 5.14, Appendix 5 will be included.

There are many instructional factors relevant to tutorial CAL and they can be grouped as follows:-

1) Introduction

2) Presentation of Information

3) Questions and responses

4) Judging responses

5) Providing feedback about responses

6) Remediation

7) Sequencing lesson segments

8) Closing

Familiarity with these factors has two purposes. It provides a basis for reviewing and evaluating teaching programs offered by others, and it provides a basis for designing one's own lessons. The lesson designer should be aware of these factors and their influences and make deliberate decisions about them when planning lessons.

The next type of CAL program is computerised drills. This ordering is intentional, since the first three teaching activities, present, guide, and practice, are well provided by having students use tutorials followed by drills on the same material.

5.6.2 Drills

Computerised drills, is a methodology used primarily for the third aspect of the teaching process, practising. Computer-based drills receive a lot of criticism. Some of this is deserved and some is not. Many educators claim that drills do not capitalise upon the power of the computer, and that they can as easily be accomplished through workbooks/problem sheets or flashcards. While it is true that most existing drills do not capitalise on the computer's power, it is also the case that the computer can be used to produce drills of much greater effectiveness than workbooks/problem sheets, flashcards or teacher/lecturer drills.

Another unjust criticism is that there are too many drills. The fact is there are not enough good drills as there are not tutorials, simulations, games or tests. The practice phase of teaching is very important, and drills in combination with tutorials and other methodologies are necessary for learning information in which fluency is required, such as basic maths skills and technology as with the 'D.C.' style program mentioned in section 5.5.1

Another important criticism is that drills do not teach, but merely practice with the assumption the student is already familiar with the information to some degree. This is true since drills are not intended to teach. Problems arise when teachers/lecturers assume a drill is capable of teaching new information and use it as if it should. Drills must be preceded by teaching methodologies that present the information and guide the student through initial learning. In computer assisted learning this might mean preceding the drill with an appropriate tutorial or simulation. It might also mean preceding the computer based drill with a classroom lesson or group discussion.

A valid criticism is that most computerised drills are of low quality. Most do not incorporate good teaching principles, and most do not collect useful information to show the teacher/lecturer how well the student is progressing. In addition, the response-judging procedures are frequently poorly programmed so that reasonable responses are sometimes judged to be incorrect.

Many people believe drills are useful only in limited areas such as arithmetic and spelling. However, the function of drills is to provide practice, and they are applicable to all types of learning, assuming that initial presentation and guidance have already occurred.

Drills may be applied to technological concepts and principles to both simple and complex problem solving in the areas of BTEC Electrical and Electronic Engineering, subjects particularly Electrical Principles and Mathematics.

Figure 5.15 Appendix 5 illustrates the general procedures of a drill.

Like a tutorial, there is an introductory section followed by a cycle that is repeated many times. Each time the cycle is repeated the following actions generally take place:

1) An item is selected
2) The item is displayed
3) The student responds

4) The program judges the response

5) The student receives feedback about the response

After a number of items the program eventually terminates. This procedure differs from that for tutorials of Figure 5.14, Appendix 5 in one major way. There is no presentation of information in a drill. In Figure 5.15, Appendix 5 that step is replaced with an item selection step.

Although most drills follow this basic format, there are variations. Some select items randomly; others select items in a specific order. Some terminate the drill after a hundred items, some after thirty minutes and some after student performance reaches some acceptable level of quality.

As with tutorials, the differences may be classified in terms of the teaching factors relevant to drills. These may be grouped in the following form:-

Introduction of drill

Item characteristics

Item selection procedures

Feedback

Item grouping procedures

Motivating the student

Data Collection

Drills have been criticised on a number of accounts. By the same token they possess advantages as well.

Drills of any sort with workbooks/problem sheets, flash cards, or a teacher, are not very interesting. Computer based drills can be made more interesting through competition, the use of graphics, informing the student of progress, and producing variety. Some of these may admittedly be used for drills in other resources as well.

The use of interactive graphics can increase the effectiveness of drills in ways not possible with workbooks/problem sheets or flash cards. The use of graphics as a prompt, as a context, as a motivator, and as feedback can all serve to make computerised drills more effective than other types.

The sophisticated queuing methods possible on a computer, which emphasise practice on items with which a student has difficulty, possess great potential for increasing drill efficiency and effectiveness. These methods are practically impossible to implement using flash cards or workbooks/problem sheets. The computers rapid computational power makes them possible. The computers unfailing memory makes possible the periodic review of retired items, presumably those that once caused the student difficulty. This too is difficult or impossible with non computerised drills. Drill Shell (1984) outlines a set of programs available from CONDUIT allowing CAL developers to produce drills incorporating these principles without programming the details of queuing and data storage.

The computerised drill programs avoid cheating. Drills of the computerised form also many provide special feedback for discrimination errors, which requires sophisticated response judging and list searching, and which is difficult or impossible for other media.

Finally the computer is very good at storing data of a number of types automatically and effortlessly. This permits better methods of item queuing, retirement and drill termination. It also permits permanent records for the student, the teacher/lecturer and the author about student performance and item quality.

5.6.3. Simulations

A simulation is a powerful technique that teaches about some aspect of the world by imitating or replicating it. Students are not only motivated by simulations but also learn by interaction with them in a manner similar to the way they would react in real situations. In almost every instance a simulation also simplifies reality by omitting or changing details. In this simplified world, the student solves problems, learns procedures, comes to understand the characteristics of phenomena and how to control them, or learns what actions to take in different situations. In each case, the purpose is to help the student build a useful mental model of part of the world, and to provide an opportunity to test it safely and efficiently.

Simulations differ from interactive tutorials, which help the student learn by providing information and using appropriate question-answer techniques. In a simulation the student learns by actually performing the activities to be learned in a context that is similar to the real world.

Simulations in contrast, may be used for an of the four phases; that is, they may serve for initial presentation, for guiding the leaner, for practice, for assessing learning, or for any combination of these. Simulations that assess learning usually do not incorporate any of the other phases, but when the other phases are present they are usually in combination.

Simulations can be divided into four main categories:-

1) Physical
2) Procedural
3) Situational
4) Process

Physical Simulation - In this type of computer based physical simulation, a physical object is displayed on the screen giving the student an opportunity to use it or learn about it. Typical examples are such programs as robot type simulations for investigation as part of microelectronics type courses in BTEC type National/Higher National Certificate courses in Electrical and Electronic Engineering. The program allows the student to alter parameters affecting degrees of freedom for the robot arm movement. Also simulation programs of a microcomputer system illustrating register and counter operation within the microprocessor element, to illustrate a way in which a program is manipulated by the microprocessor.

Procedural Simulations - Although physical simulations are very common in lessons they play a secondary role to procedural simulations. The physical simulation exists only as a vehicle for the procedural content. Thus, the student learns about how the simulated machine works, not as an end in itself, but rather as a means for acquiring the skills and actions needed to operate it. A program that simulates the important movements of a robot for example, is more likely to teach the procedures of movement rather than how the robots work.

The purpose of most procedural simulations is to teach a sequence of actions that constitute a procedure. Common examples is operating a hand held calculator which is useful for the Mathematics II of the BTEC National Certificate courses in Electrical/Electronic Engineering.

Many physical simulations are also procedural simulations, for not only is the physical entity imitated, but also the students performance must imitate the actual procedures of operating or manipulating it. In fact, the primary focus of a simulation is usually procedural, and the simulation of the various physical objects is therefore, necessary to meet the procedural requirements.

An important subset of procedural simulations is a diagnosis simulation. Here, the student is presented with a problem to solve, and must follow a set of procedures to determine the solution. Typical of these simulations are ones involving diagnosing electronic faults.

In this type of procedural simulations, whenever the student acts, the computer program reacts, providing information or feedback about the effects the action would have in the real world. Based on this new information, the student takes successive actions and each time obtains more information. A primary characteristic of procedural simulations is that there is usually a correct or preferred sequence of steps that the student should learn to perform. However, there may be many different ways of reaching the same conclusions, not all of which are equally efficient. A procedural simulation provides the opportunity to explore these different paths and their associated effects.

<u>Situational Simulations</u> - These deal with the attitudes and behaviours of people in different situations, rather than with skilled performance. Unlike procedural simulations, which teach set of rules, situational simulations usually allow the student to explore the effects of different approaches to a situation, or to play different roles in its. These type of simulations are aimed more at Business type software involving the student as an integral part of the simulation. The other roles may be performed by students who interact with the same program, or by the

computer playing the role of a person.

Process Simulations - These are different from other simulations in several important ways. The student neither participates in the simulation as with situational simulations nor constantly manipulates it as in physical or procedural simulations. Rather, the student selects values of various parameters at the beginning of the simulation, and then watches the process occur without intervention. These types of simulations are quite popular economic forecasting type programs and business planning.

The underlying flow of a simulation is shown in Figure 5.16 Appendix 5. As with both previous methodologies, there is an introduction followed by a cycle, which is repeated producing the following sequence:-

1) A scenario is presented.
2) The student is required to react.
3) The student reacts.
4) The system changes in response to this action.

Depending on the nature of the simulation, the cycle may repeat very frequently, as in a robot simulation, or infrequently, as in a process simulation where the cycle may occur only once.

As with tutorials and drills, the factors that affect the nature of simulations and influence their effectiveness.

In general, simulations have three major parts, namely:-

1) The introduction
2) The presentation and interactions
3) Completion of the simulation

Simulations typically have three major advantages over conventional tutorials, drills, and tests. The first is that they enhance motivation; the second is that they have better transfer of learning; and the third is that they are more efficient.

Motivation - Simulations enhance motivation as one would expect, if a student is actively participating in a learning situation than by being relatively passive. It is more interesting to control a simulated robot for example, than it is to read about controlling it. The same applies with the controlling of a control system. Although the "learning by doing" philosophy has been advocated by such as Bruner (1973); Papert (1972) and (1980); the introduction of computers into the educational field is likely to make its implementation more widespread.

Transfer of Learning - This refers to whether skills or knowledge learned in one situation apply in other situations. Simulations have a good transfer of learning because what was learned in the simulation usually transfers well to the real situation.

Efficiency - The idea of transfer of learning can be taken a step further. Not only is it possible to measure how effectively knowledge, skills, or information transfer from one situation to another, but also how efficient the initial learning experience is with respect to the transfer. If we consider the hypothetical case of a control system such as motor speed control. To one class you give a series of interesting and informative lectures dealing with a particular laboratory exercise. To the other class you give a computer program that provides the same information and that has a simulation of the laboratory. On completing its respective form of instruction each class performs the exercise in the laboratory. Your observation of the two groups convinces you that there is no difference in performance, and that both perform well. On the basis of this information you would be forced to say that both instructional methods have the same transfer of learning. However, if the lectures took ten hours, and the average time to complete the simulation was only five hours, you would have to say that the simulation was more efficient. That is, more transfer occurred per unit of learning time with the simulation than with the lecturer. Roscoe (1971), (1972); Povemmire and Roscoe (1973) describes in greater detail the principle of transfer.

A way in which learning efficiency in simulations can be improved is by speeding up processes that normally consume considerable amounts of time. Also simulations can enhance learning efficiency by providing the student with an environment that is more conducive to learning than the real one, since there are many distractions in real world situations.

A computer based simulation can do more than simulate the physical world. It can also simulate the lecturer/teacher. That is it can monitor performance just as a lecturer/teacher does, identify errors, and attempt to diagnose why they occurred. Prescriptive feedback can then be given to the student. The advantage of this is that a simulated teacher is always vigilant and is infinitely patient. Such simulation type software ensures the student can be given immediate feedback on performance. In addition because the feedback is provided only to the student, it can reduce personal embarrassment, which if present, would diminish the student's desire to learn.

Simulations offer other advantages too, they are safe, convenient and controllable. This is very true compared to their real life counterpart and also are far less costly. Not only are they imitations of reality, but also simplifications of it. Simplification as such teaching wise is advantageous. A person will learn faster generally if details are eliminated at the beginning of teaching.

In general some simulations can facilitate initial learning by simplifying the phenomenon. As the student becomes increasingly competent in dealing with the simple case, the simulation may then add detail to bring the student closer to reality.

Simulations are powerful learning tools, in that they encourage active learning by demanding student participation and are efficient both logistically and from a teaching point of view.

In terms of the four major phases of teaching they usually satisfy two of them: either initially presenting the material and guiding the student through it; or guiding the student through previously learned material and providing practice in it. Assessing learning is usually not combined with other phases. It is rare to find simulations that provide three or all four phases in the same lesson.

Simulations may be used as tests i.e. correct diagnosis of faults on a specific electronic circuit simulation may indicate the students readiness to fault-find on the actual equipment.

In summary simulation is an instructional methodology that uses the full power of the computer for teaching. Simulations improve on tutorials and drills through enhanced motivation, transfer of learning and efficiency. They have the advantages of convenience, safety and controllability over real experiences, are a good precursor to real experiences that would not otherwise be possible. One additional advantage is that they can be used for any of the four phases of teaching.

5.6.4 Games

Games are a powerful instructional tool. They are very much like simulations. The purpose of them as with simulations is to provide an environment that facilitates learning or the acquisition of skills. They are characterised by providing the student with entertaining challenges. It is very difficult to define a game, but it would entail to a more or lesser degree the following:-

Goals - Every game, for instance, has a goal that is either stated or inferred.

Rules - These define what actions are allowed within a game and what constraints are imposed.

Competition - Games usually involve some form of competition.

Challenge - They should provide some sort of challenge.

Fantasy - Games rely on this at times for motivation.

Safety - They can provide a safe way of acting out a more dangerous reality.

Entertainment - Teaching games use their entertainment appeal to enhance motivation and learning.

There have been many attempts to classify games amongst these being Abt (1968), Ellington, Adinall and Percival (1982). For educational purposes they may be classified by an overall generic description such as adventure games, card, board, or logic games, role-playing games, and psychomotor games.

The general structure and flow of games is outlined in Figure 5.17, Appendix 5.

Games are a powerful teaching tool if used appropriately. Schild (1968) infers that:-

> 'teachers find that games have advantages over most traditional teaching because games tend to motivate students and focus their attention on the goal of the game'.

Whilst Maidment and Bronstein (1973) postulate that:-

> 'games enhance the learning environment because the teacher plays a less dominant role and is not he only judge of performance.'

However, it is important to remember that teaching clothed in game format does not necessarily make the instruction effective. it is not the game format itself that appeals to people; it is the challenge or enjoyment of a particular game. If a game satisfied your teaching requirements it is likely to be successful and popular.

The use of games type software in further education has resided mainly in the area of Business Studies. The main area for the use of such software in BTEC National and Higher National Certificate/Diploma courses in Electrical/Electronic Engineering is in the subject of Industry and Society covering such areas as trade union relations, consumer affairs and the functioning of industry from a financial aspect. Software for such areas in a games format could be extremely useful.

5.6.5 Tests

Assessment, the fourth phase of the teaching model is an essential aspect of all teaching. it is used for a variety of purposes: determining what a student knows and does not know: rank ordering students in terms of performance; deciding who should be employed: assigning grades; admitting to next year of the course. It can take the form of an informal quiz or a strictly monitored examination. Test results can range from being of little consequence to changing the course of a persons career.

Of the two major ways to incorporate computers in the testing process, the first is use the computer as an aid to construct the test. The second is to use the computer to administer the test. Computerised test construction enables teachers/lecturers to utilise the capabilities of the computer to help generate and, often print and later score tests that students write on paper. Additionally with the proliferation of microcomputers and mainframe computers with networks of terminals, it is now feasible to administer the test directly to the student right at the computer or terminal. Both techniques offer advantages to the teacher. Both also have limitations. Wisely used, however, both can save a substantial amount of time without sacrificing quality, and they can frequently improve the quality of the testing process.

In devising such programs the following factors shown in Figure 5.18, Appendix 5 should be considered.

Tests are a crucial part of the teaching process. Because they can have such a strong influence on a student's future, tests need to be constructed with great care. The content has to be relevant to the teaching it follows, or must meet the goals of the test. The questions must cover all objectives thoroughly, and the integrity of the test should not be compromised because of the perceived time constraints. The administration of the test also has to be faultless minimising student anxiety and ensuring that logistical considerations do not interfere with the progress of the test.

However, it should be mentioned that in BTEC courses in Electrical and Electronic Engineering the emphasis is moving away from exam type testing towards assignments and Integrative Assignments which combine all areas of study i.e. testing what the student can do rather than remember. As such computer based testing would not really be satisfactory for such work. It will however, be extremely useful for the collation of grades and student records updating i.e. in a more administrative role for 'tests'.

5.7 Design and Evaluation of CAL Courseware

5.7.1 Defining Courseware

The term courseware is often used in a generic sense to describe materials that are specifically designed and produced for use within some form of teaching machine. Courseware can best be regarded as a combination of three essential commodities. It's essential constituents are:-

1) a set of teaching strategies.
2) their associated domain dependent subject matter.
3) the storage media to which each of 1) and 2) are committed.

Since the courseware considered is for teaching machines based on computers much of the teaching strategy and domain dependent subject matter will be embedded within some form of computer program. Most of the courseware will therefore, have characteristics similar to those of computer software.

Courseware for computer based systems will consist predominantly of software or programs which is augmented by material resident on other types of storage media. The following sections will, therefore, deal with techniques for design and evaluation of educational software. However, a brief section on the historical developments which have formed the foundation of modern courseware development.

5.7.2 Design of CAL Software

In Chapter 3 and section 5.5 of chapter 5 various learning models were discussed in relation to computer assisted learning. However, their greatest failing is that they do not clearly outline a methodology for actual producing software merely explaining the psychological basis for the various types of software. It is important for CAL to relate the learning characteristics to produce effective programs; which both match to student learning styles and produce the necessary motivational impetus. However, there is a need for a model which is orientated directly towards computer delivery of instruction, so it includes not only designing a lesson on paper, but also getting it into a computer and evaluating it. Alessi and Trollip (1985) proposed an eight step model to produce software in this way. It has similarities to the ISD computer model related to the work of Gagne in Chapter 3 and Chapter 5 section 5.5., but offers greater flexibility. The eight steps of the model are as follows:-

1) Define your purpose.
2) Collect resource materials.
3) Generate ideas for the lesson.
4) Organise your ideas for the lesson.
5) Produce lesson displays on paper.
6) Flowchart the lesson.
7) Program the lesson.
8) Evaluate the quality and effectiveness of the lesson.

The characteristics of these steps are summarised in Figure 5.19, Appendix 5.

The comments of the characteristics give guide lines for the production of software. However, the model is not rigid, the individual designer may change options to suit a particular case. The important point concerning this design model is that it provides the designer of courseware with a framework to work to i.e. a set of guidelines. The final step on evaluation is included in the section on this topic.

5.7.3 Evaluation of CAL Courseware

One of the basic requirements of any evaluative study of courseware is obviously to assess its usefulness and quality. An item of courseware is useful if it performs a function which, for one reason or another, the teacher/lecturer is unable to perform . Courseware quality is a more difficult thing to define and is something which is quite often assessed subjectively usually on a three point scale: good, average or bad. Obviously such an evaluation classification is not very meaningful.

A more sensible approach is the eight steps of the design model illustrated in Figure 5.19, Appendix 5, outlining the main considerations.

These considerations leave the approach quite open ended and allows for use of the Armstrong et al profiles model to be used along with interview techniques as outlined in section 5.1 as opposed to questionnaires which though, form a convenient means of collecting data on the courseware performance are open to misinterpretation. Also the questions tend to incorporate rigidity and often valid details will not come to light. This is the great advantage of the 'open' interview with the student, there being a greater freedom to comment in a constructive way.

Figures 5.20 - 5.22, Appendix 5 show some typical evaluation questionnaires which could be used and do allow some semblance of flexibility.

5.8 Distribution and Availability of Courseware

5.8.1 Distribution

The term courseware distribution implies the various techniques used by authors and distributors in order to make CAL materials available to others. The means by which courseware is distributed can vary considerably ranging from the use of postal services (via flexible discs or tape cassettes) through computer based communication networks to the most recent type of tele-software facility. The type of mechanism that is employed will depend upon the extent of involvement of the organisations concerned. Direct dispatch of courseware via tele-software facilities is in the main beyond the reach of the majority of organisations. An indirect distribution as outlined by Brown (1980) in relation to the use of 'Prestel' or Brighton Polytechnic (1982) and their use of CEFAX or ORACLE, would normally be used. However, the technique outlined by Barker (1982) using distributed computer based communication networks is possibly the more realistic approach for the majority of distributors. Barker (1982) makes reference to the fact that access to such systems is becoming increasingly easy and cost effective. In many cases an ordinary telephone via a modem can be used to interconnect a microcomputer to some distant computer enabling courseware to be transmitted between the two.

The current trend, however, is for most CAL software to be distributed via flexible discs; transfer taking place either on an adhoc basis between individual authors or through more formal arrangements based upon the use of program exchange centres to be discussed later.

One of the major motivating factors influencing the need to distribute courseware is its extremely high cost of production. Boyd (1972) suggested that:-

> 'one hour of instruction - whether it be Programmed Learning, television, Audio visual, language lab or CAL, seems to require between one hundred and four hundred hours of professional time to produce and validate.'

With the subsequent high costs that this type of involvement implies, it is imperative, therefore, that they are shared by as wide a user base as is conceivably possible. Distribution of courseware, at a reasonable cost, therefore, will ensure that as many users as possible bear its cost of production. This concept of shared development cost if of significant importance in the development of the more advanced types of courseware involving such as interactive video to ensure that cost effective courseware is produced.

A major problem with the distribution of courseware is that there is often a problem of hardware incompatibility due to software produced on say a BBC being unable to be run on an IBM. To overcome these problems a very high degree of standardisation has been introduced. Some of the different types of standards currently in use with the U.K. and recommendations/guidelines for the selection of suitable CAL courseware equipment have been outlined by Council for Educational Technology (1982) in a series of USPEC'S (User Specifications). Adoption of these guidelines should help to minimise the transferability problems. Also the use of emulators to enable interchange of software between different machines and the growing trend towards the mass use of IBM compatible microcomputers will hopefully make incompatibility a thing of the past. Other problem areas which can affect the usefulness of courseware distribution schemes are, inadequate documentation, ineffective technical support and inefficient cataloguing.

The Courseware Exchange Centres mentioned earlier owe as the primary motivation to their development the facilitation of mechanisms for courseware distribution. As a consequence of the importance of computer programs as a component of CAL courseware, organisations that archive and distribute these materials are also sometimes referred to as program exchange centres. Such centres can operate at different levels and have a variety of sources of funding. Typical levels at which these courseware exchange centres exist are:-

Local	through local authorities
Regional	through universities and polytechnics
National	through national projects/organisations
International	through international collaboration

Many local education authorities have set up educational computing centres which have been delegated with the responsibility for acquiring courseware from various sources and distributing this to schools and colleges in their local area. A typical example of a local education authority scheme is within my own LEA where an educational development centre has been in existence for a number of years to promote information technology including CAL courseware developments. Universities and polytechnics often play a similar role on a regional basis, often fostering links on an international level as well as interfacing with local centres.

Various national projects such as NDPCAL and MEP and organisations such as CET and the successor to these NCET (formed out of an amalgamation of CET and MESU the replacement for MEP in 1989) have attempted to promote courseware distribution on a national scale. However, in the main this has been in the areas of primary, secondary and special education (often through SERMERCS (Special education micro-electronics resource centres).

International collaboration can be fostered in a variety of different ways at each of the other levels of involvement.

Due to the increase in the volume of educational software, Courseware Exchange Centres have tended to specialise according to educational level, subject area and implementation language. Two organisations which came to the fore in promoting the distributing software for different education levels were:

MAPE (Microcomputers and Primary Education 1983)

MUSE (Microcomputers Users in Secondary Education 1983)

Because of the many problems associated with cataloguing and indexing courseware and computer software resources in general a project was initiated in 1983 to study possible solutions. Templeton (1983) outlined details of this project called SOCCS (Study of Cataloguing Computer Software). Its successful conclusion cannot be over emphasised in terms of the amount of human development effort it ensures is not needlessly wasted.

5.8.2 Availability

Some of the major distribution methods for courseware have been outlined in section 5.8.1. However, most of these have not generated the software/courseware for further education and in particular Electrical/Electronic Engineering courses at BTEC levels.

As a consequence the main sources of suitable software

As a consequence the main sources of suitable software has originated from the private software houses and the companies manufacturing technical equipment who have developed suitable CAL to be used with their equipment. This appears to be an area of great potential for the FE sector acquiring suitable software in the years to come. Another common source of software for the FE sector in Electrical and Electronic Engineering is via the major component distributors such as Farnell who are acting as distributors of software.

A further major source of information has become available within my own college via the Materials and Resources Information System (MARIS) database which can be logged onto via a telephone link.

Examples of the software available and the names of distributors, suitable for BTEC National and Higher National Certificate/Diploma Courses in Electrical/Electronic Engineering are shown in Appendices 5.1.

5.9 Future Directions in CAL

There are several areas in which CAL may develop over the next few years. These are outlined below.

5.9.1 Authoring Systems

A brief mention was made to authoring systems and their role in the development of courseware. It would be apt at this point to provide a clear definition of courseware.

Pogue (1980) has suggested that:

> 'The broadest use of the phrase is to encompass the entire process of developing instructional materials for the computer, beginning with the educational process of identifying the learning needs of a target population and ending with the computer process of programming the lesson as the author intended. Some people would also include the process of assessing the educational effectiveness of a lesson in achieving its intended learning outcome, but most consider this validation as separate from the authoring process'.

Pogue also offers an alternative definition when he writes:-

> 'At the opposite end of the spectrum is the another use of the phrase to refer primarily to the computer process of translating lesson material into a computer program. This definition is most likely to be by the computer professional whose interests, understandably, lie with computer related aspects of the authoring process'.

The early developments of authoring systems go back to the 1970's and the development of the TICCIT and Plato CAL systems briefly mentioned in Chapter 1. The TICCIT system was a minicomputer-based CAL system supporting a number of simultaneous learners. Up to 128 student stations could be attached to the central time-shared minicomputer system. Courseware development was able to be carried out using a special editor called APT (Authoring Procedure for TICCIT) which had proven lesson strategies embedded in it. Authors wishing to program their own pedagogic strategies into their courseware a conventional author language called TAL (TICCIT Author Language). To meet the growing needs of microcomputer based CAL MicroTTICCIT was developed for use on microcomputer systems. It allows the use of either a 'lesson generator' approach or a programming approach to courseware development. The actual authoring system called ADAPT is multi-level; offering a number of entry points depending upon both the ability of the author and the instructional design requirements of the lesson.

The PLATO computer based learning system was designed for use on a central time sharing main frame computer system that supported a large number of purpose built multi-media teaching terminals. An authoring language known as TUTOR as used to develop over 10000 hours of courseware material. Since the development of TUTOR in 1967 other versions have been produced. Notably MicroTUTOR to be used with the MicroPLATO CAL system developed for use on microcomputer systems. One of the most outstanding features of the TUTOR language is the capability it offers for handling interactive graphical images. These are produced on high resolution touch-sensitive plasma screens that are fitted to the PLATO workstations.

Since the early developments involving PLATO and TICCIT numerous authoring languages have been developed, typical examples are illustrated in Table 5.1 , Appendix 5.

A recent development in authoring systems is TOP CLASS 2 which is essentially a computer aided tutorial/presentation system for use on IBM PC's or compatible hardware. Its forerunner TOP CLASS 1.5 is still available for IBM, Nimbus, Apricot and BBC micros. The Top Class toolkit contains nine programs. Together these tools generate and deliver interactive learning. The beauty of this system is that it is effectively a low cost product in comparison to such as Ticcit and Plato authoring systems. This makes it a more acceptable proposition to the majority of potential purchasers along with the fact that in further education the majority of computers are IBM compatables.

There are a number of general requirements of a CAL courseware development tool these are:-

1) Facilities to allow both remote authoring and open/distance learning strategies

2) techniques that will facilitate group learning situations where appropriate and the need to create models of the learner, of the topics being taught, and of the subject domain from which these topics are taken.

The environment in which a student learns is another important factor that must be taken into account when considering the use of a courseware development tool. A good deal of thought must also be given to the nature of the micro or the CAL workstation that is to be employed. Also the facilities provided within the student's interaction environment are of equal importance. Such facilities require to be controlled and be used in a pedagogically effective way. If an authoring tool is employed it is imperative to ensure that it will cater for the demands of this type of environment.

There are a number of other highly pragmatic considerations which need to be made. If the author language is to be widely used other than through a distributed computer network it must be readily available, and portable across a wide range of computers with fairly low cost.

Group learning type situations can cover a wide range of instructional possibilities e.g. teaching students in automatic control system operation of complex industrial plants. Figure 5.23, Appendix 5 illustrates some typical approaches to group learning using computers.

In creating courseware to support these types of group learning activity is an extremely complex process. Very few if any, of the currently available courseware development tools are able to offer a great deal of help in this area.

Therefore, this is certainly a direction in which authoring language developments could proceed.

With reference to the authoring languages mentioned, there are clearly a wide variety of courseware development tools which are currently being employed to produce instructional material. It is a trend which is likely to continue with individuals advocating a preferred approach to authoring and the system to implement it.

Technology and particularly that associated with teaching and learning is progressing at a dramatic pace. New strategies, theories, and models of learning are continually evolving as are the new techniques for their implementation. These new ideas and concepts concerned with the role of the computer in education are gradually gaining credence. Author languages must therefore, attempt to accommodate all of these divergent changes if they are to perform a useful courseware development in the future.

Since there is likely to be a very wide range of tasks that a CAL author is likely to want to implement then the question arises of a more generalised authoring environment. A General Purpose Authoring Environment (GPAE) is needed capable of accommodating these requirements. Barker (1987) puts forward a list of some requirements for such an authoring environment. These are shown in Table 5.2, Appendix 5.

5.9.2 Intelligent Tutoring Systems

Artificial Intelligence (AI) can be regarded as part of the overall field of computer science. It has often proved difficult to attach a clear definition to it due to the difficulties in defining exactly what human intelligence constitutes, never mind intelligence in a machine. For the purposes of our discussion Winston (1979) provides a quite uncomplicated definition:-

> 'It is the study of ideas that enable computers to do the things that make people seem intelligent.'

Some of the earliest work in the introduction of AI into educational courseware was described by Carbonell (1970), Siklossy (1970) and Wexler (1970). Their investigations dealt mainly with generative computer assisted learning and computer-based tutors that had an 'awareness' of what they are taught. Since these early studies man valuable contributions have been made to the development of what has now become known as Intelligent Computer Assisted Learning (ICAL). Among the most notable of these are reflected in the studies reported by Brown and Burton (1978), Clancy (1979), O'Shea (1979) and Gable and Page (1980).

Human instructors are intelligent teachers. it would seem reasonable therefore that CAL software should be designed and fabricated in such a way that it attempts to implement at least some of the intelligent behaviour that human teachers/lecturers exhibit. Of course, this will require that the software has the ability to deal with unanticipated situations is a similar way to the human teacher/lecturer. It is highly probable that the implementation of such software would need to be developed as a result of research in the area of artificial intelligence.

Many designers of courseware believe that it is important that the software is able to build up a mathematical model of the student in terms of his/her ability, preferred learning modes and knowledge states. Comparison of the values of characteristic parameters of the model for given student instances with desired values, would allow appropriate teaching strategies to be automatically and dynamically created. These could then be used to automatically control the path that the learning process takes for each individual student. Software that fulfils these objectives exists on the larger types of computer system. However, whether the complexity of this software will permit its implementation on small computers remains a possibility for the future.

The major problem with artificial intelligence research has been, that once a particular project has been completed, researchers have one headlong into the new areas. This has opened up. The result has been that projects have not been implemented. However, we would do well for future research to heed the words of Duchastel Doublait and Iurbean (1988):-

> 'Intelligent computer assisted instruction (ICAI) constitutes an applied domain of artificial intelligence which shows much promise not only for extending the range of learning resources made available to students and trainees, but also refining and formalising our intuitive conceptions of teaching.'

Clearly the benefits from an educational and in particular CAL viewpoint that are to be reaped in the future from AI in establishing a better understanding of the learning and teaching process. This in itself will be mean achievement. The results could mean the production of CAL in the future which more nearly suits the individual students needs.

One of the more useful products to emerge from artificial intelligence research as outlined by Michie (1979) has been the concept of an 'expert system'. There are two broad roles that aim expert system might fulfil within a CAL environment; advisory and instructional. In its advisory role an expert system could be used to provide advice about particular courses of action relevant to any given situation or sets of conditions that could arise during CAL orientated activities. As an example, it could advise an instructional designer on how best to set up a particular CAL configuration in order to meet specified teaching/training requirements. Similarly such a system could be used to analyse student behavioural data and offer advice to lecturer/teacher or student about appropriate counselling, tutoring or instructional strategies.

In its instructional role an expert system is able to make explicit both its own knowledge and its mechanisms of inference in order to aid a student's learning activity. This can be achieved through the use of specially designed human-computer didactic dialogues. An alternative to this is via knowledge-driven courseware. This is teaching software that calls upon one or more knowledge bases in order to derive its instructional material and strategies. An approach of this type is often referred to as knowledge based CAL.

The classic case of an expert system for use in electrical and electronic engineering courses such as BTEC National and Higher National Certificate/Diploma utilising knowledge representation is a program call SOPHIE see Brown et al (1975). This program is designed to teach students how to trace faults in electronic apparatus. It operates by presenting the student with a circuit schematic of the device. In this case a stabilised low voltage power supply into which has been introduced a fault of some specific degree of difficulty. The student's task is to trace this fault, after requesting various circuit measurements and suggesting a solution. Then the program checks the solution in terms of his/her consistency with what should have been learned about the circuit in making these measurements.

Sophie uses powerful inference making procedures applied to a simulator to evaluate the student's solution to the problem in the particular context determined by the set of measurements he/she has made. Despite being a very large program it has a fast response time comparatively of three seconds. One built in assumption is that the student will have some prior knowledge of the basic electronic principles underlying the design and operation of D.C. Power Supplies. The measurements he/she takes will therefore be based on their mental model of the power supply. If this is incorrect inevitably an incorrect solution will result. Sophie unfortunately is not sufficiently intelligent to explain why it is wrong. Hence though it appears an efficient program problems highlighted above cast doubt on it real educational value.

An important point to bear in mind is that it highlights a potential area of use. As well as electrical/electronic fault diagnosis expert systems could be utilised in the design procedures for electrical electronic and computer circuit and systems. This is an area where if the present high prohibitive costs of expert systems can be overcome, along with their suitable adaptation on IBM compatables and similar microcomputers the potential is enormous. These are certainly areas within the BTEC course in Electrical/Electronic Engineering that such expert systems could be used to good effect. In both individual subject areas and also project and assignment work, students could greatly benefit from the use of such systems.

5.9.3 Interactive Video

A brief mention to interactive video was made in Chapter 4, as one of the more recent computer based learning tools. There are already systems available for both Acorn and Research Machines microcomputers, probably the two most widely used range of micro's in primary and secondary education. ACORN machines (BBC micros) are still prominent in further education establishments.

There are important educational initiatives already under way concerning interactive video. Dillon (1988) highlights the Interactive Video in schools project (IVIS) which was essentially a research and development project. Its brief being to explore the educational use of interactive video in the widest sense incorporating the Domesday project see Walker (1988). In September 1987 the Interactive Video in Industry and Further Education (IVIFE) project was set up with a 1.9 million pounds grant from the Department of Trade and Industry to develop interactive video materials for use in industry and further education.

The five projects involve Fault Finding in Advanced Electronics, Printed Circuit Boards - A board in one, The training Needs of Trainers, Turning Tools and Effective Teamwork.

Wright and Dillon (1988) maintain that:-

> 'The convergence of the two technologies, video and computing has enabled the development of a learning and teaching tool which is flexible enough to cope with the needs of both student and teacher.'

This would appear to be a valid comment in the light of demonstration of IV seen by the author. Additionally in educational terms it strength is that it allows the learner to have control over the medium rather than vice-versa as is the case with much of the educational SOFTWARE available at present.

Along with the above initiations and the work outlined by Wright (1988) concerning the Domesday project in the Mathematics classroom, clearly IV has some real potential as a future CAL resource. The major constraints on its future development and widespread use are the economic and political forces at work on the education system and acceptance by the teaching profession as whole. The introduction of IV has certainly enhanced the prospect of future multi-media CAL workstations outlined by Barker (1987), becoming a reality in the future.

5.9.4 Distance/Open Learning

The main characteristics of these methodologies have been outlined in Chapter 4. However, this is an area where computer-based communication networks represent another very appealing method of implementing open/distance learning systems.

With the rapid developments in both information technology and communications it is not unreasonable to assume that future approaches to CAL are likely to involve the integration of each of the two basic methods, microcomputers and communications. Barker and Yeates (1985) see this being achieved as follows:-

> 'through the use of highly distributed computer communication networks and global nets combined to reproduce an integrated highly distributed CAL system.'

Figure 5.24, Appendix 5 illustrates the typical layout of the network mentioned above. This sort of system does not seem out of the question. It was announced in January, 1989 by the Director of Education for Walsall Tuck (1989) that:

> 'all Walsall schools participating in the TVEI scheme would be networked and links with industry established. It being the intention to keep Walsall schools at the forefront of Information Technology developments.'

Certainly if the money is provided and other LEA's take similar initiatives then it seems that in the near future that a number of Intelligent Computer Managed Distance Learning Networks put forward by such as Gray (1988) will be a realistic proposition. These offer the advantages of a multi-site, multi-media environment and above all multi-national capability. Also legitimate user access only and a high degree of flexibility.

There would exist learner tracking assessment and guidance as well as courseware assessment. A 'CALNET' project to demonstrate this project is underway. The possibilities for education are inviting, CAL has reached a watershed but because of the converging and new technologies it is possible to 'swamp' the learning environment i.e. it should lead to a valuable learning experience taking us into the 21st century.

5.9.5 Comments

This chapter has attempted to identify the types and modes of CAL courseware. Examine their general characteristics, design and evaluation, methodology and the approach of relating models of learning to these CAL methods in order to develop effective learning programmes.

As a final consideration the future developments of CAL have been examined as a forerunner to the investigations into the state of present day CAL within BTEC National and Higher National Certificate/Diploma courses in Electrical and Electronic Engineering at various colleges of F.E. This area is examined in depth in the subsequent Chapter 6.

CHAPTER 6

SURVEY OF CAL IN ELECTRICAL/ELECTRONIC ENGINEERING DEPARTMENTS OF FURTHER EDUCATION COLLEGES

6.1 General

In attempting to research CAL developments of electrical and electronic engineering it was decided to look at it from three main fronts. A survey of lecturer's views on different aspects relating to CAL in various colleges of F.E. and two case studies, 1) observing a class over a period of time operating in a CAL type environment 2) observation of a class using different courseware in two different lessons.

As a result of this research it was hoped to relate the real effects of curriculum changes in recent years, in technician education with the subsequent developments in CAL. Another important facet was to be able to put the current position of CAL in Electrical and Electronic Engineering BTEC courses into its true perspective.

6.2 Methodology

Before outlining the methodologies used to conduct the above mentioned research it would be as well to define educational research. A definition which is both simple and adequately sums up what is attempted to be achieved in this work is that put forward by Powney et al (1987), which refers to it as:-

> 'The systematic, empirical and critical inquiry into matters which directly or indirectly concern the learning and teaching of children and adults.'

By empirical it referred to that of being observed reality, whether reality is an experimentally contrived or controlled one, or whether it is careful observation of some aspect off people's everyday experience. The inquiry is not intended to be random, but related in a systematic way to hypotheses or propositions being held and developed by the researcher, or it may be derived from the empirical data assembled. In both natural science and in normative methods in social sciences, observations confirm or reject previously stated hypotheses. Inductive reasoning used in interpretive approaches in the social sciences allows propositions or hypotheses to emerge from careful observations. Such hypotheses can then be considered in the light of further observation, or even a re-examination of the research data.

The subsequent methods used in the research will now be considered in the following sub sections.

6.2.1 <u>Surveys</u>

Surveys typically accumulate data at a given instant in time. The intention of these is usually to a) describe the nature of existing conditions, or b) identifying standards against which existing conditions can be compared or c) determining the relationships that exist between specific events. Hence surveys can vary in their complexity levels, from those providing simple frequency counts to those presenting relational analysis.

The techniques used to gather data in a survey would typically involve the following; structured or semi-structured interviews, self-completion or postal questionnaires, standardised tests of attainment or performance and attitude scales.

The latter two techniques are for very specific cases or areas of educational research. Therefore for the purposes of the survey involved with the work outlined in previous chapters, consideration will be given to the interview and questionnaire type techniques as they offer the appropriate means of data gathering for the survey.

The questionnaire technique has one major attribute in particular, that is it can be distributed to a large number of people easily via the postal system. However, it does have a number of major pitfalls. The first is one of the rigidity of the questions which are often open to misinterpretation. Secondly the response to this technique is often very poor. Typically only about 40% of questionnaires are returned based on personal experience.

The interview technique takes on several forms. A formal interview in one where set questions are asked and the answers recorded on a standardised schedule. In contrast to this is the less formal interview in which the interviewer is at liberty to modify the sequence and wording of the questions, explain them or add to them. The final form is the completely informal interview, where key issues are raised in a conversational style instead of having a set questionnaire.

The concept of the interview technique is defined in very precise terms by Cannell and Kahn (1968) as follows:-

> 'a two-person conversation initiated by the interviewer for the specific purpose of obtaining research relevant information, and and focused by him on content specified by research objectives of systematic description, prediction or explanation.'

It allows for the most, or least, structured examples of interviews. The methodology of it is unusual in that data is gathered through direct verbal interaction between individuals. This is quite different from the questionnaire where the respondent is required in some way to record his/her responses to set questions. The overall merits of the two methodologies are summarised in Table 6.1, Appendix 6.

The direct interaction of the interview is in fact the source of both its advantages and disadvantages as a research tool. One advantage is that it allows for the greater data. On the other hand, a disadvantage is that it can be prone to subjectivity and bias on the part of the interviewer.

In comparing the merits of the two techniques it was decided that advantages of using an interview technique compared to a questionnaire outweighed it disadvantages. This was particularly so in the sense that a completely open minded flexible approach was required to be adopted in order to illicit the fullest information from the participants.

With these factors in mind an interview questionnaire was developed as shown in Table 6.2, Appendix 6 to be used in the less formal style interview mode described earlier. Hence the use of a 'general comments' questions to ensure the participants are able to give full range to their views on CAL.

A problem which had to be overcome was how to record the data. Either to use a tape-recorder and transcribe the conversations or to use a 'written approach, recording answers as they are given in a handwritten form. After a mock interview using a tape-recorder and transcribing the conversation it was clear that this would be an extremely long winded process in terms of the possible number of participants to process. Hence it was decided to record the answers given to the questions in a written form.

The Heads of twelve Electrical and Electronic Engineering Departments located in colleges of further education were contacted by phone as an initial approach for permission to conduct the survey. Permission was granted by all twelve and the covering letter sent out as a follow up to the telephone conversations, see Figure 6.1, Appendix 6. The results of this survey are covered in detail in section 6.3.

6.2.2 Case Studies

The basis of the case study technique is the observation of the characteristics of an individual unit such as, a child/student, a clique, a class, a school or a community. The main purpose of such observation being to probe deeply and analyse intensively the multitude of phenomena that make up the life cycle of the unit with a view to establishing generalisations about the wider population to which the unit belongs.

There are two primary types of observation, the first known as participant observation and engages the observation, the first known as participant observation and engages the observer in the activities he sets out to observe. Non-participant observation involves the researcher standing aloof from the group activities he/she are investigating i.e. positioned at the rear of a class in the case of classroom observations.

Bailey (1978) identified the following as inherent advantages in the participant observation approach:-

1. Observation studies are superior to experiments and surveys when data is being collected on on-verbal behaviour.

2. In the observation study, the investigator is able to discern on-going behaviour as it occurs and is able to make appropriate notes about its salient features.

3. Because case study observations take place over an extended period of time, the researcher can develop a more intimate and informal relationship with those he is observing, generally in more natural environments than those in which experiments and surveys are conducted.

4. Case Study Observations are less reactive than other types of data - gathering methods. For example, in laboratory-based experiments and in surveys that depend upon verbal responses to structured questions bias can be introduced in the very data that the researcher is attempting to study.

Whilst these are extremely valid and pertinent points, participant observation studies are not without criticism.

Typical critiques that have emerged are its, subjective, biased, impressionistic, idiosyncratic and lacking in the precise quantifiable measures that are the hallmark of survey research and experimentation. Clearly there are obvious limitations to observation methods, which offset the advantages. In order to challenge these critiques the participant observer may use a broad strategy of participant observation outlined by Denizen (1970) which he termed 'analytical induction' to validate data collected. Further to this the overall possible advantages outlined by Adelman et al (1980) proffer a strong case for the use of case studies in education research see Figure 6.2, Appendix 6.

The final two research studies considered in this work involve the use of CAL courseware by students in the classroom environment. This fact plus the completely open minded approach to be adopted to these make observational techniques an extremely attractive proposition for use with these studies.

In the case of the first study purely participant observation is used with the lecturer being the observer. However, in the second one, both participant and non-participant observation techniques are utilised.

A further technique for the evaluation of the courseware used in the case studies is the use of classification profile models discussed in Chapter 5. The use of these varied techniques with the final two studies introduces the idea of a further methodology triangulation.

Triangulation is defined by Cohen and Mannion (1980) as follows:-

> 'as the use of two or more methods of data collection in the study of some aspect of human behaviour.'

As such it tends to offer the advantage of providing a more complete overview of human behaviour and of situations in which human beings interact. Also the more the methods contrast with each other, the greater the researcher will generally have in the data collected. A final advantage is that the use of triangulation techniques overcome the problem of what is termed 'method boundness' i.e. it makes use of a number of methods rather than contrasting one method against another.

The actual case studies and their outcomes are discussed in detail in section 6.3.

6.3 Research Studies

6.3.1 Survey

Of the original twelve colleges contacted eight eventually followed up the letter sent to them and arranged for staff to be interviewed. The eight colleges were from the West Midlands, Staffordshire and Leicestershire areas. In all 42 staff were interviewed on an individual basis using the questionnaire outlined in section 6.1. With the freedom to add any comments as they felt were necessary to their viewpoint in addition to the answers given to the directed questions.

The breakdown of the number of lecturer's interviewed at each of the colleges is indicated below with the possible numbers in brackets. In order to keep the colleges anonymity, they have been designated by a number.

College 1	-	16	(16)
College 2	-	6	(6)
College 3	-	5	(7)
College 4	-	6	(20)
College 5	-	1	(20)
College 6	-	4	(5)
College 7	-	2	(5)
College 8	-	3	(20)

Because of the comparatively small numbers at each college it is difficult to carry out comparisons between them with any real justification. Therefore most of the results will be analysed on the total population of the survey. As and when it is felt that comparisons between colleges can be made, reference to them will be indicated.

Question 1 - The data was used to indicate the percentage of staff involved in the respective BTEC ONC/D and HNC/D courses and the percentage of staff involved in the main subject areas of the national and higher national certificate courses. These results are produced as bar graphs shown in Figures 6.3 and 6.4 respectively.

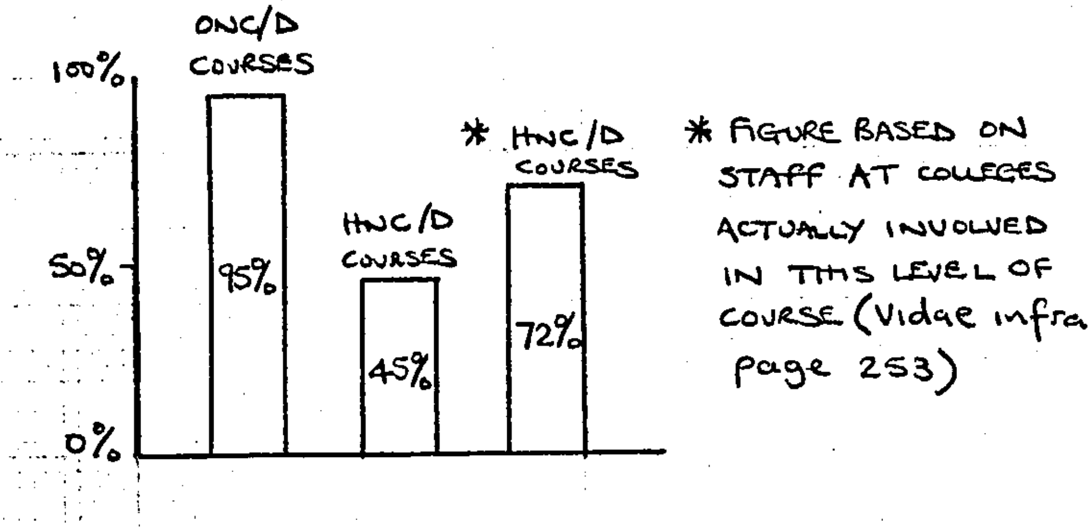


FIGURE 6.3 - THE PERCENTAGE OF STAFF INVOLVED IN BTEC ORDINARY AND HIGHER NATIONAL CERTIFICATE/DIPLOMA COURSES

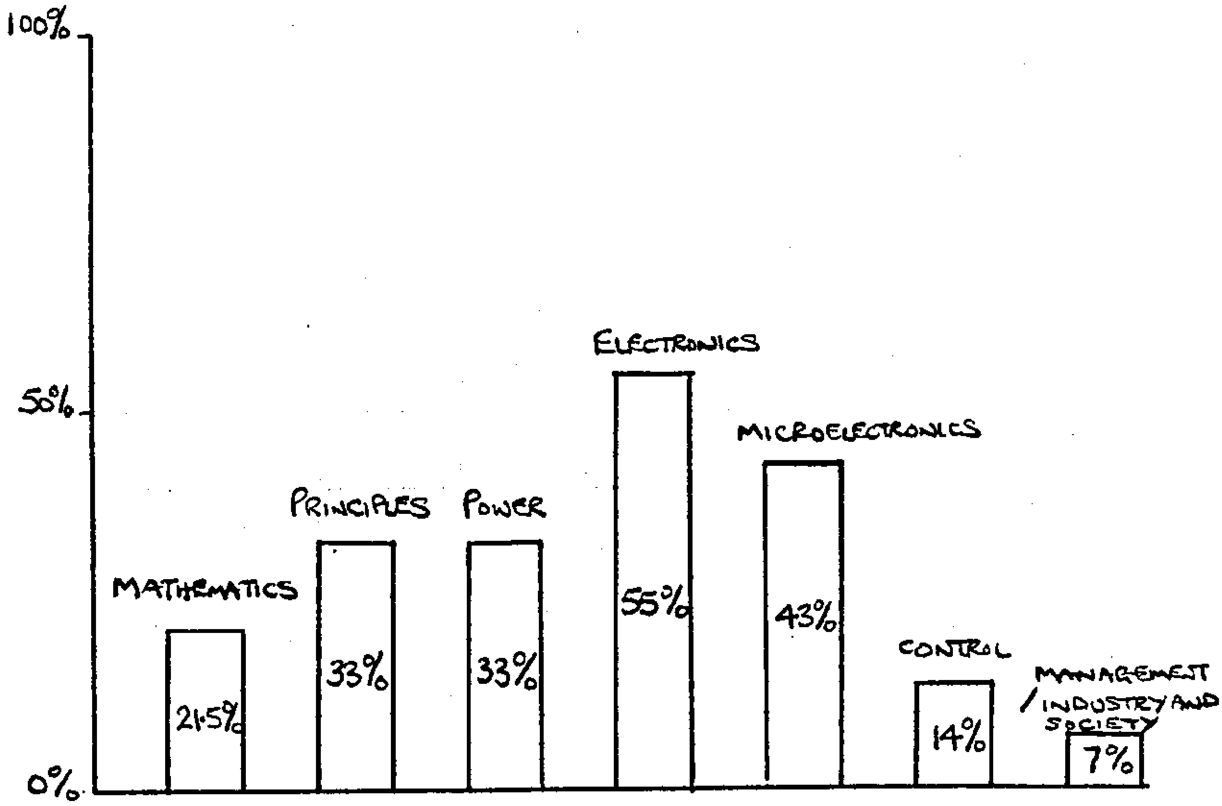


FIGURE 6.4 - THE PERCENTAGE OF STAFF INVOLVED IN INDIVIDUAL SUBJECT AREAS ON BTEC NATIONAL AND HIGHER NATIONAL CERTIFICATE/DIPLOMA COURSES

<u>NOTE!</u> Power refers to all subjects under the guise of heavy electrical engineering i.e. Electrical Applications, Utilisation of Electrical Energy, Electrical Machines etc. Electronics refers to both analogue and digital subject areas.

The results of graph shown in figure 6.3 are as one would expect with most of the staff interviewed being involved with BTEC National Certificate/Diploma level courses only as this is the highest level of BTEC course in electrical/electronic engineering at the college. This was the case for colleges 2, 3, 6 and 7. The remaining four colleges undertook BTEC HNC/D level courses. The figure of 45% staff coverage for such courses is based on the total survey population. If this is related to considering only the staff at the colleges taking these higher level courses the figure is 72%. This clearly shows that staff within the survey are given a good spread of work in terms of the level taught.

The graph of figure 6.4 clearly shows that more of the staff involved in the survey teach in the subject areas of electronics and microcomputing. This is not surprising considering the rapid developments in microelectronics and information technology which has put such subjects to the forefront of technician education. Nonetheless a healthy percentage staff are involved in teaching the power subjects, which is still a vital area within the electrical/electronic engineering field. Similarly a good number of staff are involved with the core subjects of maths and principles which is to be expected as they are regarded as common subjects for all staff. The indication in the mathematics subject area is that the subject is now commonly being taught by electrical/electronic engineering staff rather than by Maths specialists. his indicates a move in the direction of integrating the idea of mathematics as tool a for the technical subjects area rather than being a separate entity.

A smaller percentage of staff are involved with teaching control both because of its specialism and the fact that a good deal of control is incorporated into the microprocessor syllabuses. Management studies and the study of 'industry and society' are 'minority' subject areas in the overall BTEC scheme for electrical and electronic engineering and as such there is less likelihood for a large number of staff to become involved in such subject areas, hence the small percentage figure for staff representation within this subject.

The major purpose of this question was to obtain a picture of staff involvement in both levels of course and the different subject areas. It was hoped to illustrate the potential market areas for the development of CAL. The likelihood being that the greater the depth of staff coverage the more likelihood that CAL would have of being introduced.

Question 2 - This question attempted to establish some idea of the teaching strategies being utilised by the staff at the eight colleges. Figures 6.5 represents the results of this data. The percentage figures quoted are for those staff utilising either traditional (teacher) centred strategies, student-centred or a mixture of both strategies.

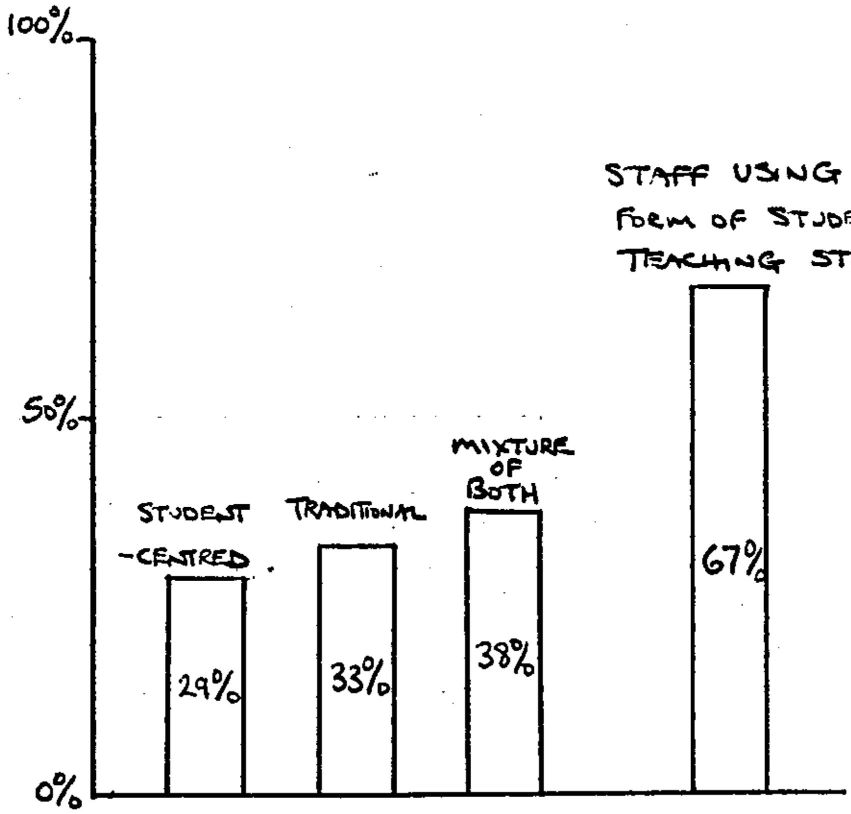


FIGURE 6.5 - PERCENTAGE DISTRIBUTION OF STAFF USING A PARTICULAR TEACHING STRATEGY

The graph illustrates that the figures for staff using student-centred and traditional teaching strategies is fairly even, with slightly more using a mixture of both strategies. The real significance of these results is that clearly the number of staff now using some form of student-centred teaching strategy in the region of 67% i.e. two thirds. This would indicate that staff appear to be attempting to follow the BTEC curriculum philosophy of the recent schemes towards a more student-centred approach as detailed in Chapter 2 on curriculum.

Another interesting observation concerning these results is the fact that nearly forty per cent of the staff involved in the survey are using a mixture of methods. This can be attributed to a number of factors:

1) They wish to provide variety to increase student motivation.

2) They are attempting to match lecturer teaching strategy with the students learning strategy as outlined in Chapter 4, for different topic/subject areas, i.e. attempt to accommodate all students needs.

3) They are using a mixture strategies in order for self motivation and fulfilment.

The most important implication as far as CAL development is concerned is the fact that so many staff are using some form of student -centred learning. CAL was identified in Chapter 4 as one of the methodologies attributed to student-centred learning. Hence there is clearly a growing favourable environment for CAL development and application to take place.

Question 3 - In this question the objective was to ascertain the type of computer used for teaching and the purpose of use. The graph in Figure 6.6. illustrates the main types of computers used by the staff:-

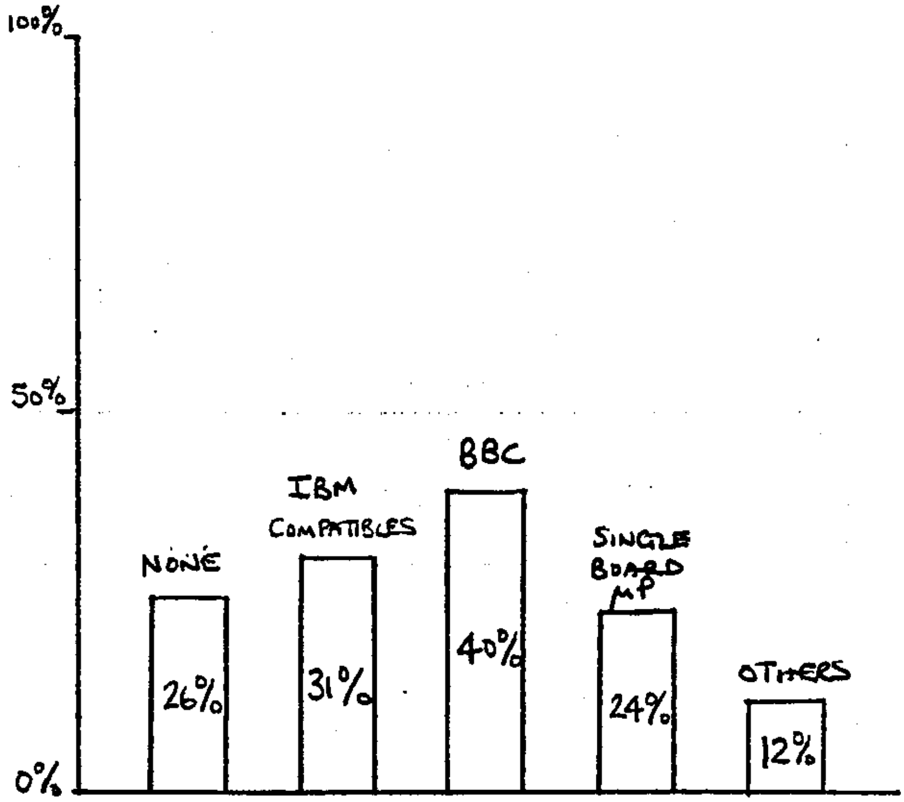


FIGURE 6.6 - PERCENTAGE DISTRIBUTION OF USE OF TYPES OF MICROCOMPUTERS FOR TEACHING PURPOSES

It is clear from the graphical analysis that just over a quarter of the survey population do not use any computer in their teaching. Of the remainder there appears to be three main computers IBM compatibles, BBC and the single board microcomputers, with the BBC appearing to be the most widely used. This is probably due to the fact that in the early days of the PC type computer the BBC was the one adopted for mainly wide educational use. Various equipment manufacturers latched on to this and produced equipment to be used on it. As a result it came to be widely used in further education in engineering type departments. However, since the inception of IBM compatibles as industry based standards and their decreasing costs electrical/electronic engineering departments have gradually acquired more of these type of micros to keep pace with industry. In the early days of microcomputer/microelectronics studies the main form of micro used was the single board micro and this appears to still a popular choice, due probably to its low cost and natural use of machine code and assembler languages which have long been main programming languages for engineering type applications.

In the case of the applications for which the computers have been utilised in the teaching environment Table 6.3 illustrates a breakdown of them with percentage figures for staff usage.

APPLICATIONS	%USAGE BY STAFF
Not used in Teaching	33%
Assembler/Machine code programming	24%
Basic Programming	19%
Pascal and C Programming	5%
As a controller and for interfacing	24%
Word Processing and Desktop Publishing	29%
Computer Aided Design-Printed Circuit Board or Circuit Design	31%
Computer Assisted Learning	19%

TABLE 6.3 - OUTLINE OF TEACHING APPLICATIONS FOR MICROCOMPUTER WITH PERCENTAGE STAFF USAGE

From this table of results it is clear that only 67% of staff made use of the computer for teaching purposes. The main uses being for computer aided design and word-processing/desktop publishing. This is not really surprising considering the accent placed by BTEC on 'learning by doing' (see Chapter 2 on curriculum), and via such vehicles of learning as the integrative assignment: which attempts to integrate all the various skills areas both practical and communication wise. Hence there is a ready made platform for the use of such applications.

The above applications are closely followed in terms of usage by the teaching of assembler and machine code languages and the use of the microcomputer for interfacing and control purposes. These areas of application fall into the microelectronics systems subjects and as such one would expect them to be covered by the staff usage percentages quoted. Another factor to emerge was that BASIC still appears to be the most widely used high level language, nearly four times as much as Pascal and C. This is probably largely due to two main factors, most staff were introduced to high level language programming via the Basic programming medium and also it is readily available on BBC computers which constitute the largest proportion of those used.

As far as the use of CAL type learning applications, this is restricted to one in five teaching staff involved in the survey. The likely reasons for this are discussed in conjunction with question 7 data.

Question 4 - This question attempts to highlight the programming languages favoured for the use by the lecturing staff. Some staff favoured the use of more than one language and as with previous questions percentages are related to number of staff using or involved with a particular item.

Figure 6.7 illustrates a bar graph of the resulting data.

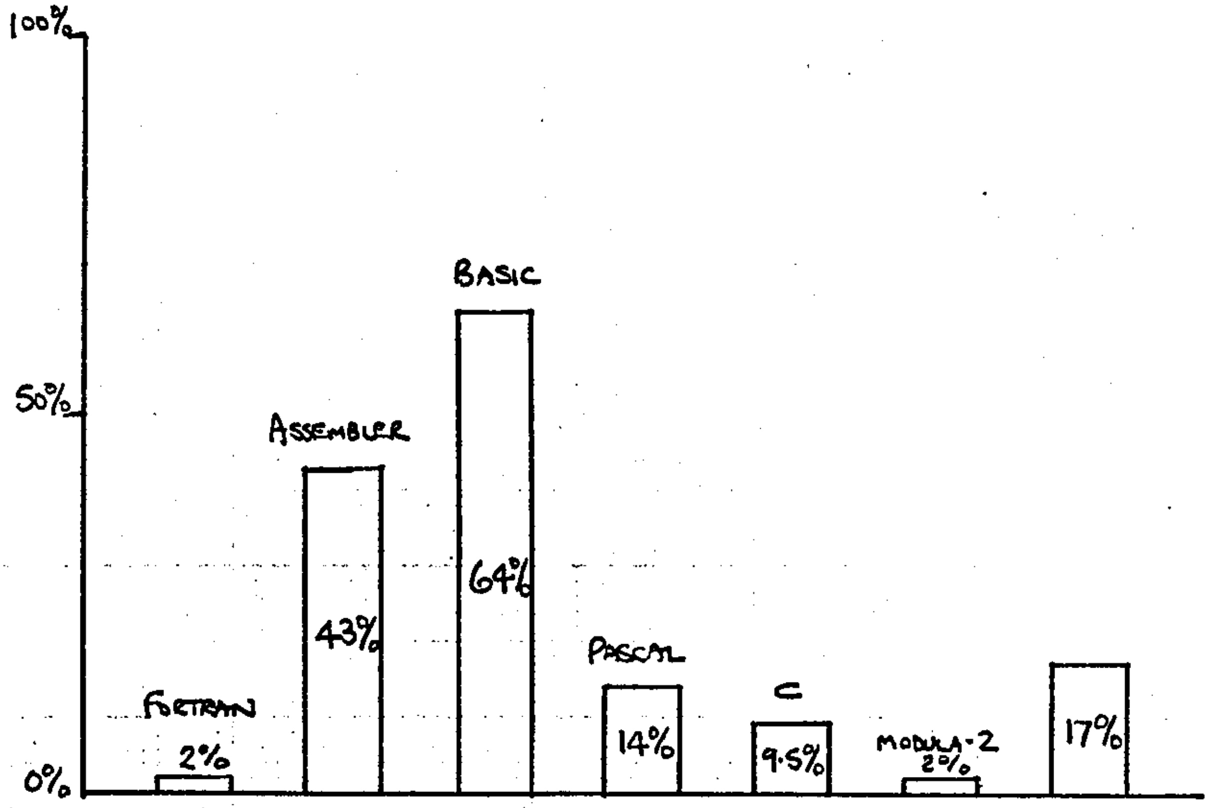


FIGURE 6.7 - PERCENTAGE DISTRIBUTION OF PROGRAMMING LANGUAGES FAVOURED BY STAFF

It would appear from the data that Basic and Assembler are beyond doubt the two most favoured languages for use with the students. This is understandable when one refers to the previous comments regarding applications when both were discussed.

From a CAL viewpoint, clearly if software/courseware was to be developed by staff involved within this survey then it would probably be using the BASIC programming language. No mention at any time was made to authoring systems by any of the survey population.

Question 5 - It was the intention of this question to establish an idea of how the survey population viewed computer assisted learning.

Something like 88% of the lecturers interviewed defined it, with slight variations in each case as a computer resource for assisting the learning process as part of a student-centred learning strategy. In the region of 10% regarded it as being an extension of the programmed learning concept using a computer. The remaining 2% had difficulty in defining it.

The important point to emerge from this in terms of CAL development is that a minority saw it as merely programmed learning in another guise and no-one regarded it as a replacement for the lecturer/teacher. These are two fears that have tended to perhaps hold back the development of CAL to any great degree with colleges of further education. As the saying goes 'Old values die hard '. It is refreshing therefore, to see the very positive viewpoint regarding what CAL is.

Question 6 - This question sets out to determine the actual use of CAL by the survey population in their teaching environment. The graph of Figure 6.8 illustrates the results.

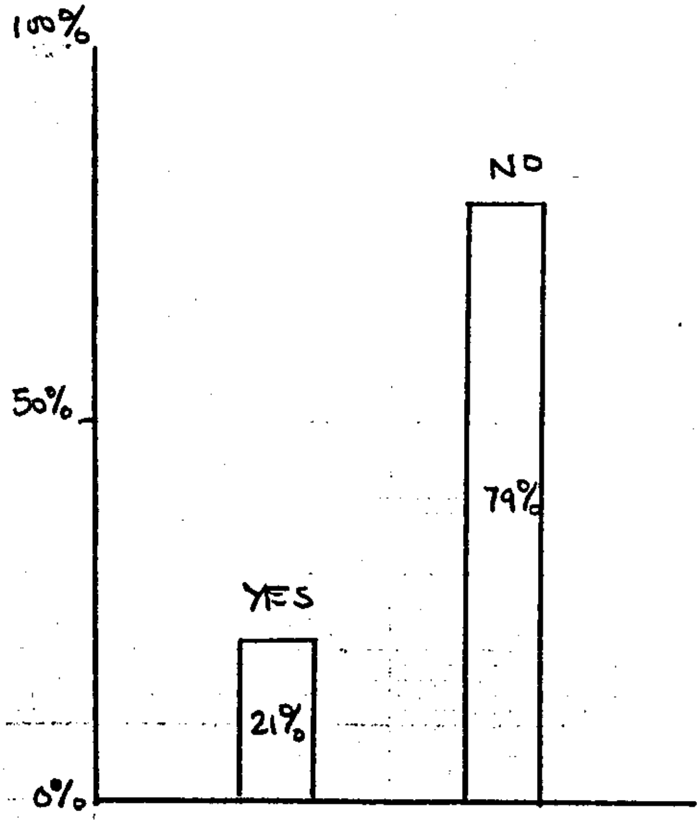


FIGURE 6.8 - USE OF COMPUTER ASSISTED LEARNING BY LECTURING STAFF

The results show as was indicated in terms of the applications in Question 3 that approximately 1 in 5 staff make use of the CAL resource. Reasons for this will be related to the data of Question 7.

Question 7 - This attempted to highlight the reasons why CAL was not being used. All but five of the survey highlighted the main reason for not using CAL was the lack of hardware and facilities i.e. suitable rooms and the lack of suitable software. In other words the underlying problem has been identified as lack of resources.

Of the lecturers who differed in their viewpoint to the above, two highlighted their main reason as being a lack of experience in applying such techniques.

The other reasons highlighted by the remaining lecturers were as follows:-

'Not convinced it works.'
'Never found a niche for it.'
'Because it does not give real effect.'
'It gets in the way, students concentrate more on running the computer than actual principles.'
'Because it does not make use of computer. Could be put into a book.'
'Not enough simulation packages.'

All the above are valid reasons for not using it, reflecting the lecturers experience with CAL. What is important is that all viewpoints on CAL are aimed openly and made widely know to senior college management, courseware developers and distributors alike to ensure that adequate facilities, hardware and courseware products are provided that will encourage both an increased and wider use of CAL.

Question 8 - This question assess the level of interest in using CAL. With the exception of three of the survey population there was a very definite interest in using CAL if it is of the right quality. Of the three remaining lecturers only one was not interested in not using it and this was due to impending retirement. In the case of the other two, one was prepared to use if forced to, and the other if it was optimum thing to do.

The results show that among the survey there is an overwhelming interest using CAL as a teaching resource. This clearly exudes hope for the future development and application of computer assisted learning.

Question 9 - In this question the overriding object was to obtain a clear picture of the way CAL was being utilised in the classroom. The following examples resulted from the interviews.

Use in conjunction with real control engineering applications to simulate plant control type operations in the subject of engineering applications of computers.

Students used menu drive software working at their own pace with the lecturer providing assistance when necessary.

Used as and when students needed to review work and preferably with a test facility incorporated.

Another case was students investigating software packages as a group and learning from experience. The lecturer was present to stimulate learning and thinking it was about reinforcement since the work had already been covered in a traditional sense.

In other instances it was used purely for demonstration purpose and also as an 'hands on' approach with a simulation style package.

CAL was used in some circumstances in its role as a student-centred resource to aid and support the normal teaching.

It was also used to create a computer/student interaction for the purpose of teaching Pascal programming.

A final example was in a full lesson with the lecturer acting as a facilitator.

These various examples illustrate some of the ways in which the CAL has been used. What is significant is that the way that a CAL packages use in interpreted can have a variety of connotations and is dependent on the flexibility and creativity of the lecturer. A further point in no way was it mentioned that it was a replacement teacher or used in that context.

Question 10 - This was intended to elicit from the survey population the types of software they had used.

A wide variety of software had been used. In terms of software associated with that actual computer, compilers, and assemblers had been used on IBM machines.

The more commercial type software such as word-processing packages including Wordwise, and Wordstar Professional, data bases, desktop publishing i.e. 'Ventura' and spreadsheets.

In terms of computer aided design packages such as Turbo-CAD (for IBM compatibles) and PAEN and Pineapple (for BBC micro) had been plus ORCAD for both digital and analogue circuit/system design, and SPICE for analogue circuit simulation. As far as printed circuit board design was concerned 'Vutrax' and 'Ranger' were typical of the system used. Also the use of a CAD/CAM system to produce a library of electrical/electronic components.

A range of software from Farnell distributors mentioned in Chapter 5 including the tutorial/simulation style operational amplifier and digital circuits courseware. Also a package on D.C circuit principles in the tutorial/drill and practice mode. CNC type simulation software to simulate the operation of computer numerical control machines had been used in one case. A program call CODAS from Manchester University had been used (available for both IBM and BBC machines) for design and calculation tasks in control systems such as for graphical work on locus. Nyquist diagram, root locus, transient and frequency response plots

The final types of software used were for digital control/simulation purposes, an example the Bytronic range of equipment, sequencer, sorter, and d.c. motor control, where it is used both to control and simulate a plant style control environment.

These results provide an overall picture of the type of software being used and highlight of CAL which will be discussed in Chapter 7.

Question 11 - The idea of this question was to attempt to elicit information in order to build up a picture of what CAL developments need to be carried out in the future to meet the aspirations and requirements of lecturers in electrical and electronic engineering. A number of interesting pointers emerged from the interviews and are outlined in the following paragraphs.

There was felt a need for greater number of purpose built rooms for CAl, providing accessible hardware provision. Software of an acceptable quality was needed to satisfy the precise BTEC course/subject needs on a wide scale. In tune with software needs mentioned were several other useful comments. Present CAL is too specific and therefore, easily out data. A more generic software should be available for ever and a day.

The concept of resource centres with a wide range of dedicated software packages. Tied in with this idea is the further development and applicability of interactive video systems.

The idea of its use for promoting an open learning approach in assignments and projects was noted along with its development hand in hand with student-centred learning. In conjunction with this idea the use of self teach packages was mentioned, being widely made available and producing a facilitator role. The only worry with this was that it could be seen as a replacement for the lecturer in management eyes.

The use of self assessment style packages of the computer managed learning (CML) style which monitor and assess the student were deemed a valuable future trend for CAL. Voice type program i.e. the development of the human computer interface was mentioned. A final general point that was made is that software/courseware should be produced by people with the technical background who are conversant with what is going on in BTEC electrical and electronic engineering courses.

Specific reference was made to the development of more simulation and control type packages with the accent on increased speed in such as logic circuits type simulations.

It was felt that there was also a need for more principals style packages to be developed and computer aided design with the accent on circuit simulation. There was one comment casting doubt whether CAL had any place in the further education college, more likely in a training environment.

A large number of these comments reflect the lecturers response to Question 7 which indicated the under use of CAL due to lack of hardware/software availability and suitable facilities in which to house them. There also seems to be a definite trend in terms of the type of software to be developed. Simulations style software would appear to be in demand for use in future. These ideas will be developed further in Chapter 7.

Question 12 - The main areas of interest in software usage have attempted to be identified by the data from this question.

A large number of the survey population as identified in the data of Question 11 wished to use simulation type CAL packages in a number of areas, control, microprocessor hardware, analogue and digital circuit design and operation PCB design and word-processing software packages also appeared to be popular.

A number of other key areas identified where electrical principals in teaching some of the more difficult concepts of A.C. theory. Also the subjects of Building services incorporating electrical distribution and cable selection, plus the design of electrical installations. A further use on the power side of electrical engineering was packages for plant utilisation and the solution of energy calculations. Other areas of interest involved use of software to assist laboratory experiments i.e. plotting results, computer literacy, administration and for programming purposes.

Somewhere in the region of 10% of the survey population were interested in using it in all subject areas including mathematics.

Clearly from the above areas of interest of software usage there is a need for software to cover a wide range of fields particularly CAL with the emphasis on a simulation style.

Question 13 - It was the intention with the data from the interviews to ascertain the survey populations feelings - regarding the current quality of software in the various subject areas of BTEC electrical and electronic engineering courses. A bar graph was produced to illustrate the spread of viewpoint, and is illustrated in Figure 6.9.

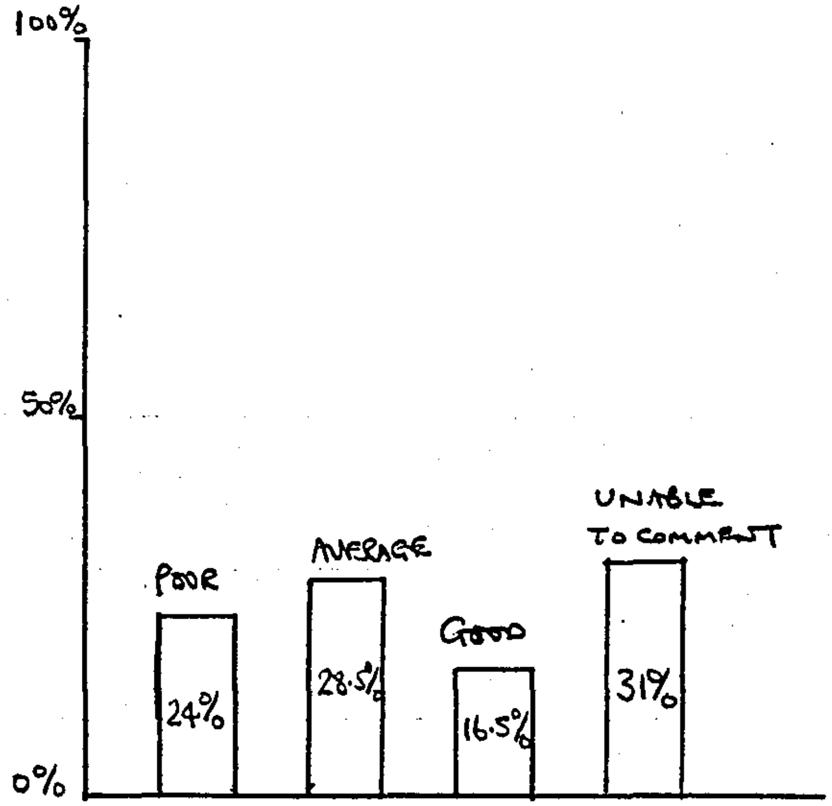


FIGURE 6.9 - PERCENTAGE FIGURES FOR LECTURERS' COMMENTS ON THE QUALITY OF CURRENT EDUCATIONAL SOFTWARE

From the interviews, 31% of the survey population were unable to comment on the quality of software, having not been involved with the use of it. As a consequence the bar graph of the data was based on the two thirds of the sample who were actually able to comment. From this data the following figures were produced 35% rated the software they had used or seen as poor, 41% thought it average, and 24% regarded it as being of good quality. It would be incorrect to make widely based deductions of this data with such a small population sample. However, certain facts emerge; approximately two thirds of the sample actually involved in using software had found it of at least an acceptable quality. Whilst this leaves a good deal of room for improvement in the development of CAL courseware it at least indicated that courseware does exist which is usable and provides a basis for future improvements.

Question 14 - The results of the data from this question attempt to provide an overview of the desirable features required in good quality software. Comments that were generated from the interviews have been rationalised into a twelve point plan, which if adhered to by courseware designers would provide lecturers and students with software of a good quality.

1) User friendliness - i.e.

2) Colourful concise displays with high quality graphics.

3) Not too much flashing between screens with a minimum of text, neatly laid out on the screen for clarity.

4) Good on-screen instructions and help facilities.

5) Highlighting of items.

6) Sensible logically structured progression through the program in terms of the learning process level and embodying technical correctness.

7) Students able to be in major control of software in order to acquire knowledge with the minimum of help.

8) High quality content coupled to the courseware being aimed at the correct level. It should be the job intended for it i.e. providing a direct correlation to BTEC syllabus's in electrical and electronic engineering.

9) The courseware should have pre and post testing facilities in built, including tests to monitor students attainments as he/she progresses through the program. This is in order to provide feedback to the student and remedial work if necessary.

10) The courseware should be cost effective and system compatible.

11) Documentation should be readable, concise and and appropriate to student needs and level.

12) Above all the courseware should be stimulating and provide strong motivation to the student.

Clearly these comments bring out the main factors which should be considered in developing courseware and though they are not the viewpoints of every lecturer, but a mixture of views nonetheless they produce a coherent pattern of factors which are all valid in such an instance, and tie in with some of the ideas expressed in Chapter 5.

From the general comments which were added at the end of the respective interviews a number of interesting additional points arose.

CAL should be developed by professional programmers and in conjunction with lectures/teachers to produce good software.

The development of courseware is expensive resulting in a very low return potential, which does not make good business sense. This results in a slow development process for CAL production.

Staff are not receiving the necessary training with computers and CAL. As a result neither are being exploited to their full potential. It requires a commitment on the part of college senior management towards staff development and increased expenditure on hardware/software equipment.

New developments should be directed towards young staff irrespective of rank or position.

CAL is a facility which could make things take off and could eliminate or cut down on a lot of unnecessary detailed note taking. This would help to improve the BTEC philosophy of making a student responsible for his/her own learning.

A few comments generated a somewhat pessimistic view and are summarised as follows:-

Difficult abstract concepts, difficult to do on the computer which is pre-programmed, whereas a teacher gives variations.

There are reservations about its use in the classroom, only really to be used as a backup.

It is often used because it is their, not because it is the best educationally.

The final point echoed was whether there will ever be enough money to be able to use CAL effectively in the classroom.

It is the intention to discuss these comments in the conclusions in Chapter 7.

6.3.2 CASE STUDY 1

This study was carried out with a group of first year BTEC National Diploma in Electronics students. The class totalled sixteen in number and was of three hours duration. Two subject areas were to be covered Industry and Society (1 unit) and Engineering Applications of Computers (1/2 unit). The syllabus's for these are shown in Appendices 6.1 and 6.2., Appendix 6.

In the main this case study covers observations made during the subject of Engineering Applications of Computers, and in particular the last ten weeks of the subject which accounts for 60% of the work, section E - Use of Computer

Systems in Engineering. Because of the availability in terms of numbers of equipment, then a matrix plan had to be used to ensure that all students had access to the equipment over the allotted ten weeks. The layout of this plan is shown in Table 6.3, Appendix 6. This plan incorporated the use of the following pieces of equipment:

8 - BBC B+ microcomputers
+ IBM compatibles
1 - Pneumatic Sequencer Unit)
1 - Bead Sorter Unit.) plus
1 - D.C Motor Control Unit.) software
1 - BBC Buggy.)
1 - 'PAEN' Computer Aided Circuit Design Software Package.
1 - 'WORDWISE' word-processing software package. 'WORDSTAR PROFESSIONAL' software.
1 - Robot Simulation software package.

The layout of the room for this lesson is shown in Figure 6.10, and enables there to be two students per activity.

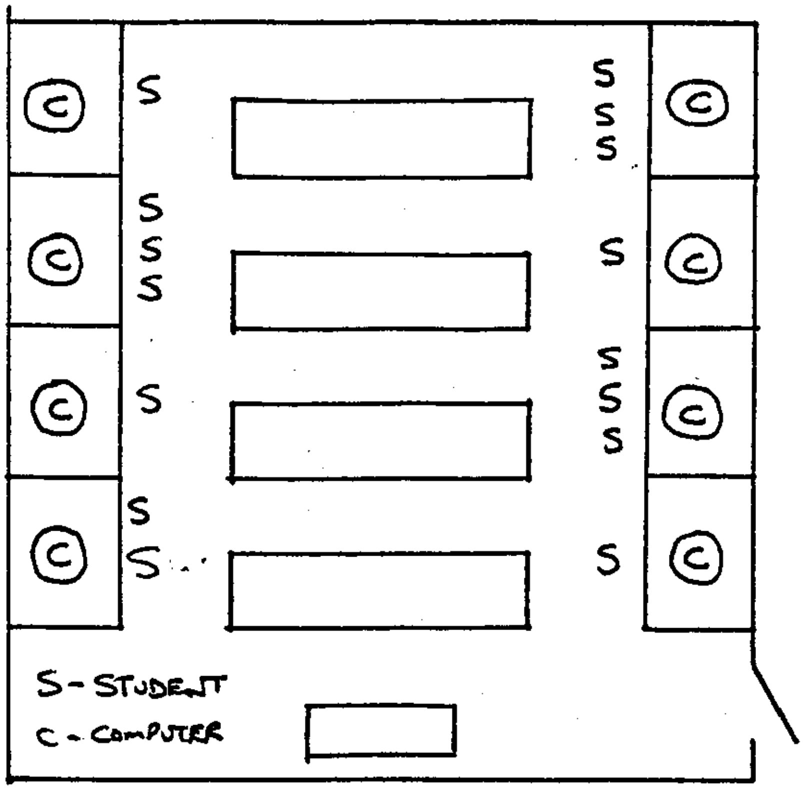


FIGURE 6.10 - ROOM LAYOUT FOR LESSON IN ENGINEERING APPLICATIONS OF COMPUTER'S SUBJECT.

Before discussing the observations mention must be made of the equipment and its purpose.

The'Paen' software package 'Circuit Designer' was used in conjunction with a BBC Model to reproduce a circuit diagram, save it to disc and print it out. This formed the basis of assignment No.2 of the unit covering the specific objective, uses a CAD.CAM system to carry out an operation appropriate to the students occupation. The assignment and an example of the print out are shown in Figure 6.11, Appendix 6.

The 'Bytronic' bead sorter and BBC B microcomputer plus associated software enable the student to satisfy the specific objective C - Uses a computer system to sort materials or components. This system allows the student to utilise all available menu options and experiment with time delays and entry of his/her own assignment 3 which is covered by this work is shown in Figure 6.12 in Appendix 6.

The 'Bytronic' Pneumatic controller is again used with a BBC B microcomputer in order to satisfy objective, in section E - Uses a computer system to control a sequence of physical operations e.g. the sequential control of pneumatic/hydraulic valves and actuators or the use of a programmable controller. Again the student is able to different time delays and entering of their own parameters. Figure 6.13 in Appendix 6 illustrates the assignment No.4 based on this equipment.

The Bytronic 'D.C' Motor Control Unit and BBC B hardware plus the software package allow the student to investigate digital motor control. Provision is made in the Software to enable the students to obtain some concept of control. This equipment enables the students to satisfy the specific objective f - Uses a computer system to perform a simple process control task e.g. data logging or PID control.

Use is also made of the BBC 'Buggy' and microcomputer which allows the students to program a path for the buggy to follow. Again this illustrates the idea of digital control in relation to such industrial applications of the automatic control of pallet trucks as used at Rover "Longbridge".

The robot simulation is a software package enabling the student to operate a simulated on screen robot via input at the keyboard of a BBC microcomputer, and also Wordstar professional for gain experience for preparation of report and for use with the final assignment No.5 illustrated in Figure 6.14, Appendix 6. This is an exam test on disc using the word-processing packages mentioned and covers question on section A-D of the syllabus.

In the actual case study the author was the lecturer involved and therefore, very much a participant observer. The lessons on this unit were very much on the student-centred strategy approach with the lecturer acting as a facilitator .

Throughout the lessons the students were extremely well motivated by the courseware provided on the whole. It tended to generate excellent interaction between the individual students in the groups and between the different groups. Ideas appeared to be 'bounced' around to solve problems as they occurred. The lecturer was only consulted in cases of real difficulty and interactive discussions took place to lead the student towards a solution rather than giving an answer. Another important factor noticed over the period of these lessons was that the computer tended to help the student concentrate on the job in hand rather than the mind wandering in a normal classroom lesson.

The students, after discussion with them made the following points:-

They enjoyed the freedom to move around rather than being tied to a desk. In terms of the software they found on the whole, that it was extremely stimulating and the computer as a tool. Hence it falls into the emancipatory mode as outlined in Table 5, Chapter 5. The robot simulation on the other hand falls into the Revelatory category. With these categories in mind the students were asked their opinions on the software in terms of how it had affected their motivation and whether they felt that they needed any basic skills before tackling the assignments mentioned. Also the observer's own observations into the motivation levels and level of skills/knowledge needed was taken into account. The purpose behind this was to evaluate the software with reference to the Armstrong et al classification profile models discussed in Chapter 5, Section 5.5.

In the case of the software in the emancipatory mode there was overall an extremely high level of motivation and students were able to build up the various conceptual structures, general strategies and appreciation with reasonable confidence based on their previous background knowledge. However, most felt that without some previous knowledge they would have reached the level of understanding that they had achieved by investigation and trial and error.

The robot simulation package proved to be badly presented in terms of the graphics and was very limited. Students became very bored with it after about 20 minutes having investigated all its possibilities. From an understanding viewpoint and development of conceptual structures and general strategies it provided no problems.

From these observations and comments the following profiles for the software were produced as shown in Figures 6.15 - 6.20. These make use of the following third axes :-

1) Rote to Understanding.

2) Motivation as a continuum based on the research findings of Day and Berlyne (1971).

3) An axis based on technical competence in the use of the CAL and hardware.

What should be appreciated both with case studies 1 and 2 is that they are very much based on subjective observation.

The classifications produced are not quantitative, but qualitative, attempting to represent an evaluation of the software from a pictorial viewpoint, to generate discussion and ideas for software development, rather than presenting it in terms of actual figures which can often mislead.

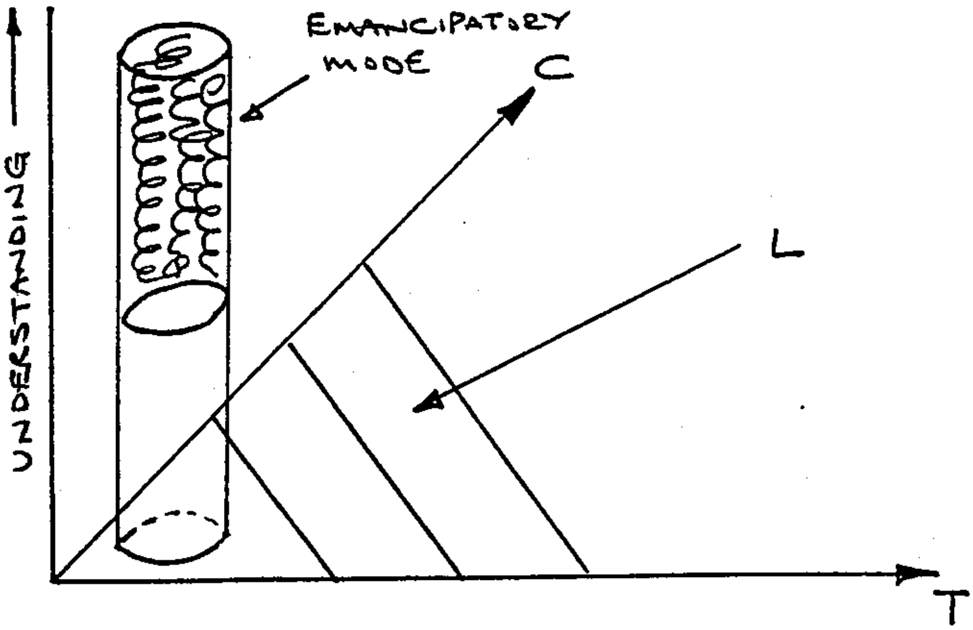


FIGURE 6.15 - EMANCIPATORY SOFTWARE LEVEL OF UNDERSTANDING

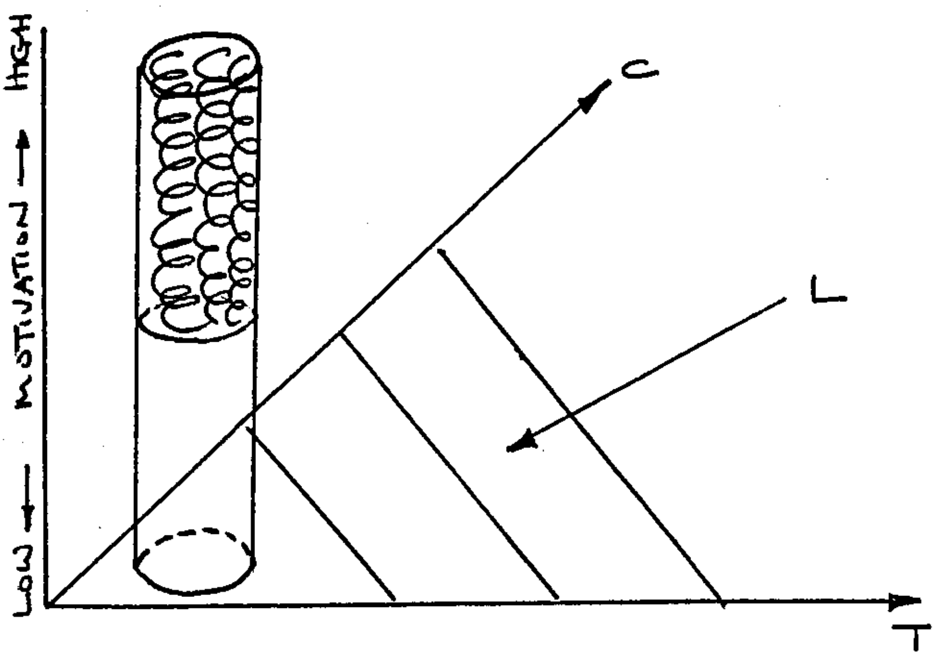


FIGURE 6.16 - EMANCIPATORY SOFTWARE LEVEL OF MOTIVATION

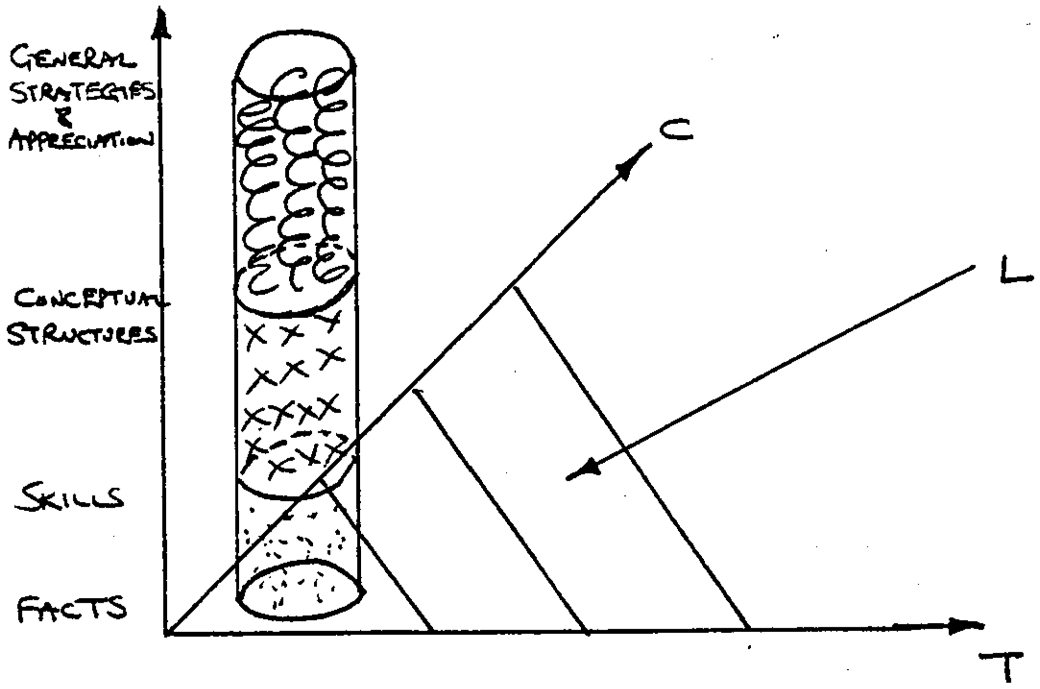


FIGURE 6.17 - EMANCIPATORY SOFTWARE LEVEL OF TECHNICAL COMPETENCE

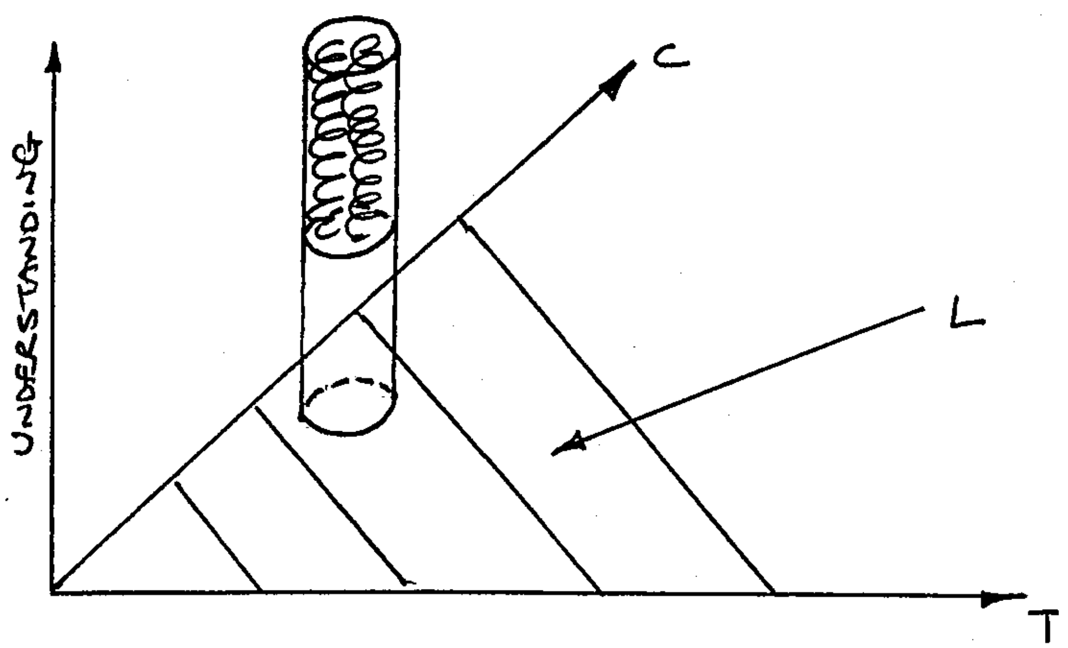


FIGURE 6.18 - REVELATORY SOFTWARE LEVEL OF UNDERSTANDING

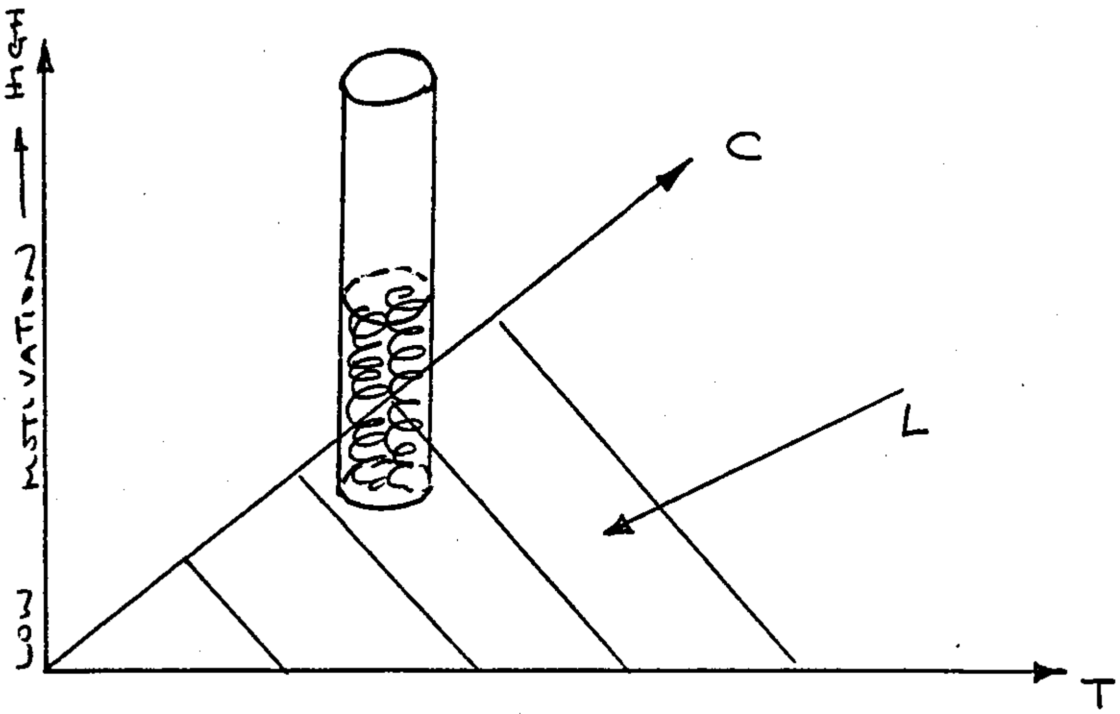


FIGURE 6.19 - REVELATORY SOFTWARE LEVEL OF MOTIVATION

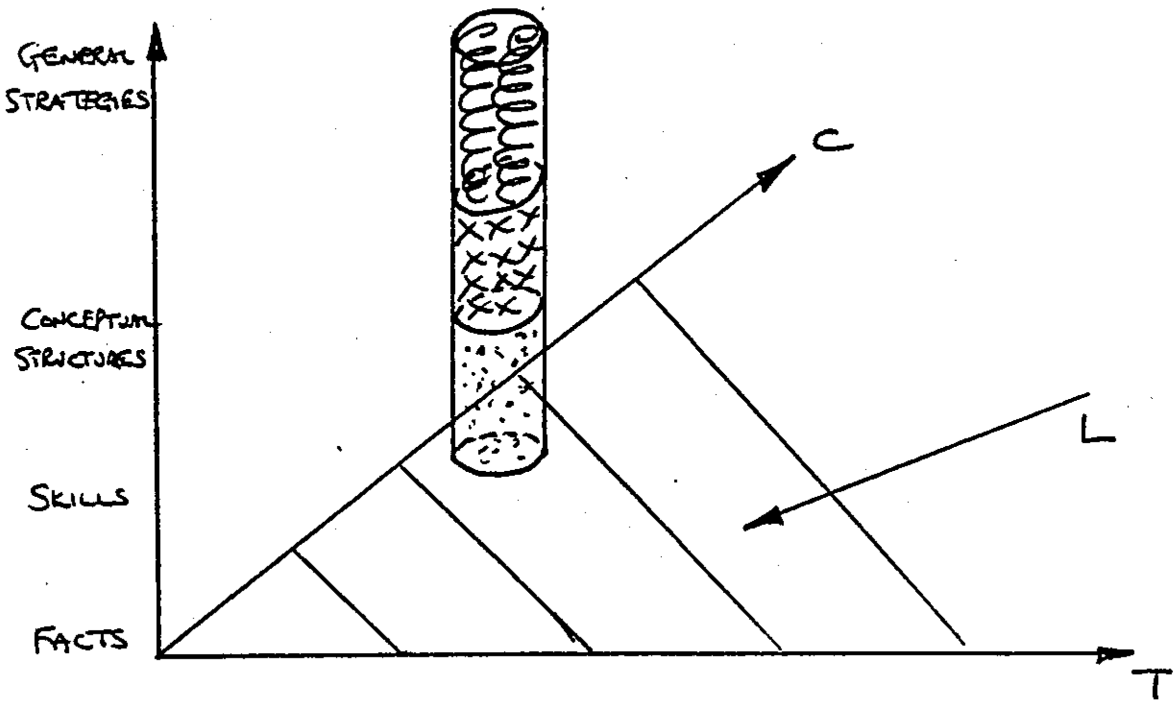


FIGURE 6.20 - REVELATORY SOFTWARE LEVEL OF TECHNICAL COMPETENCE

The above mentioned profiles were established in the following manner. In the case of both the emancipatory and revelatory modes types of software examined the levels of understanding achieved was determined by the participant observer (lecturer in this case) questioning the students about the system as they progressed through their investigation of it and noting their replies. Also from questions asked by the students and the way they responded to the lecturer prompting them to establish the answer for themselves. Their technical competence was established by observing the way students approached the investigation of a particular systems setting up operation and application, and how they tackled and overcome the various problems as they arose. In terms of their motivational level to the systems and software, this was ascertained by observing the students expressions and general enthusiasm for using it. Students views about how they liked the software were taken into account as well.

These diagrams clearly illustrate the major factors we need to consider when evaluating software.

1) how control was apportioned.

2) the mode of use.

3) the degree of understanding.

4) the motivational value.

5) level of technical competence achieved.

The bubble effect illustrates regions of probability. In the case of technical competence the different shaded areas illustrate the case may be, that facts and skills are needed to develop the conceptual structures and general strategies and appreciation. On the other hand we may not, or they have been acquired prior to using the software. These profiles in effect paint a picture of the quality of the software and allow for easy comparison between software of different modes, particularly if in the same topic area.

The profiles emphasise the major problem with the robot simulation; its lack of motivation and a greater preponderance towards computer control rather than learner control compared to emancipatory type CAL.

Reference should also be made to the Industry and Society module mentioned earlier, although no actual CAL was used in teaching it. Again, however, a very much student-centred approach was adopted to the subject matter. Students working in small groups of four researched each Principal Objective of the syllabus and presented a talk to the whole class plus a piece of written work which formed the assessment.

In the principal objective on the Information Technology developments, use was made of a Video' Welcome to My World' portraying the possible information technology type society in the year 2000 based on decisions taken in connection with the development of I.T in the 1980's and

90's. Students were asked to put their own views on the way the Information Technology revolution is evolving and contrast them with those on the Video.

It became quite clear from teaching this subject that there were two major possible applications areas for the use of CAL within it. The first is the use of GAMES type software in connection with the principal objectives on Trade Unions and the Commercial and Business aspects and policies, to create an illustrative atmosphere, making these topic areas more meaningful. In the case of the second application this would be the use of Interactive Video to allow students to develop their talks, with both text and pictures making for much more vibrant and meaningful talks.

6.3.3 Case Study 2

This study was based on a part-time day 1st year National Certificate class. It involved two consecutive one -three quarter hour lessons covering the subject of Electronics N III (3 units). The first one incorporated the Analogue Electronics element of this subject and the second the Digital Electronics element. A copy of the syllabus covering these elements is shown in Appendices 3 and 4, Appendix 6.

In the Analogue Electronics class the lecturer was also the participant observer. A software package on Operational Amplifiers Megacycl Software was used. This was a simulation/tutorial style package. Since the simulation elements were in the main used throughout this lesson it was classified as being in the Revelatory category.

The BBC model B computer was used to run the software on. There were only seven students in the class and the room layout was as shown in Figure 6.21.

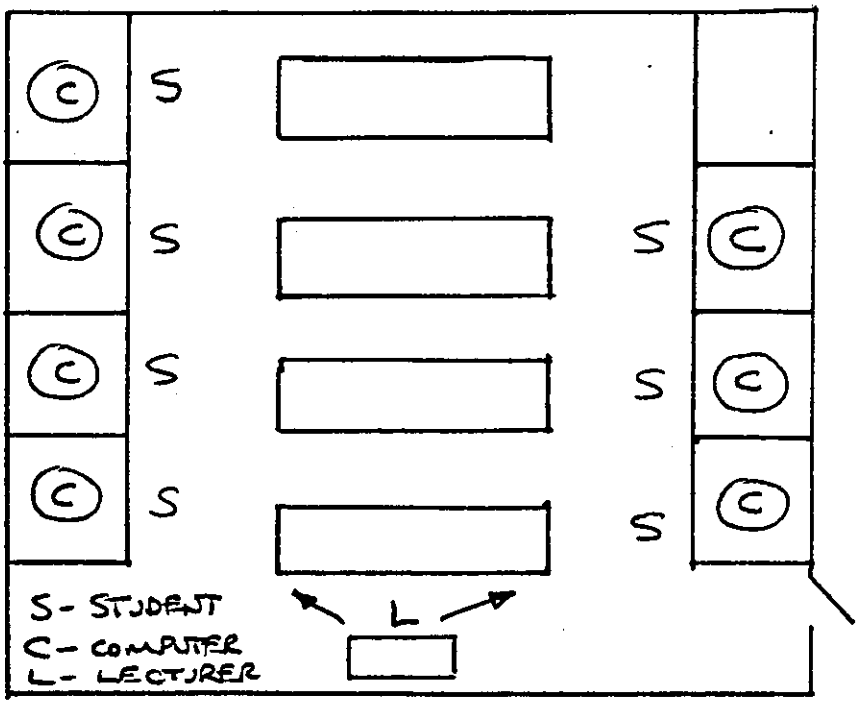


Figure 6.21 - ROOM LAYOUT FOR CASE STUDY 2

It should be made clear that the students were well used to student - centred learning approaches, and had started to investigate operational amplifier circuits practically and therefore, had some background knowledge.

The intention of using the software was to extend the students knowledge of the circuit parameters by investigating the effects of altering their values.

As with case study 1, the software concentrated the students attention. It lead the class to discuss amongst themselves the various effects exhibited by changing parameter values.

The lecturer was brought into discussions in his role as a facilitator when students needed clarification of concepts or to discuss quality of software. They referred to documentation whenever necessary rather than the lecturer.

All the students worked diligently through the package extracting the information from each section they needed and then moving through to the next menu option. At the end of the lesson the group expressed their comments on the software/courseware which are summarised as follows :-

1) Very user friendly with good graphics.

2) Software was very applicable to the present work being carried out on operational amplifiers. It acted like a library of information concerning parameters with simulated on screen examples of operational amplifier configurations that enable parameters to be changed and effects observed.

3) A very useful visual aid having an excellent format.

4) There could have been greater on screen textual explanations.

5) There should have been set tasks to guide the student.

6) Documentation was considered to be of a very high quality.

7) Overall with one exception the software was considered a very useful usable visual aid which the students would be very happy to use in future tasks on op - amps.

This viewpoint was echoed by the lecturer who regarded it as a much more informative and interesting source of information than a library investigation. A further combined lecturer/student view as its applicability to the subject level and content.

In the case of the lesson on the Digital Electronics the room layout was exactly the same. The main difference being that there was a non - participant observer separate to the lecturer. Although since it was the same the same as for the analogue electronics lesson, the students related at times to him. Hence the observer could deemed in fact to be a participant observer.

The software package used was Digital Circuits by Garland Software, which via a menu driven program enabled the student to identify logic symbols, study design of combinational logic circuits such as flip - flops, counters, registers etc.

The lesson followed the same general pattern as for the analogue lesson with very good inter-student and student-lecturer interactions taking place. Unfortunately the overall quality of the software was not as good as it might have been with resulting loss of motivation as the lesson progressed. This generated the following student group and lecturer comments:-

1) Due to its somewhat poor editing facility in the circuit design menu option and poor help facilities generally it was deemed not very user friendly.

2) There appeared a number of bugs in the system, as an example when answering or responding to question prompts, even with correct response the question was repeated as if a wrong answer had been given.

3) The documentation though well presented in terms of its explanation of actual digital circuits left something to be desired in informing the user concerning the actual program use.

4) It was felt that the content of the package related well to the syllabus content and would act as a good revision tool as well, providing the bugs and editing facilities were eliminated and improved respectively. The flip-flop menu option was considered exceptionally good and a valuable aid for information prior to practical implementation circuits.

5) The general comment made was that as the software stood it was unsatisfactory for general use due to problems outlined above and would tend to put people off using CAL packages.

An evaluation of both the analogue and digital software packages using classification profiles is shown in Figures 6.22-6.27.

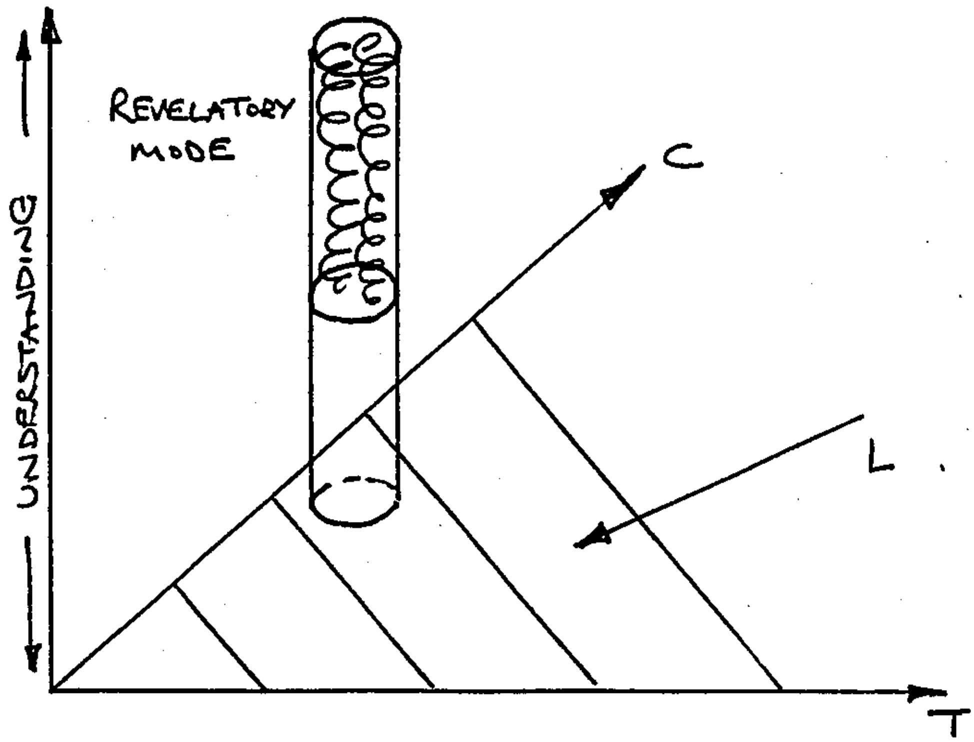


FIGURE 6.22 - ANALOGUE SOFTWARE LEVEL OF UNDERSTANDING

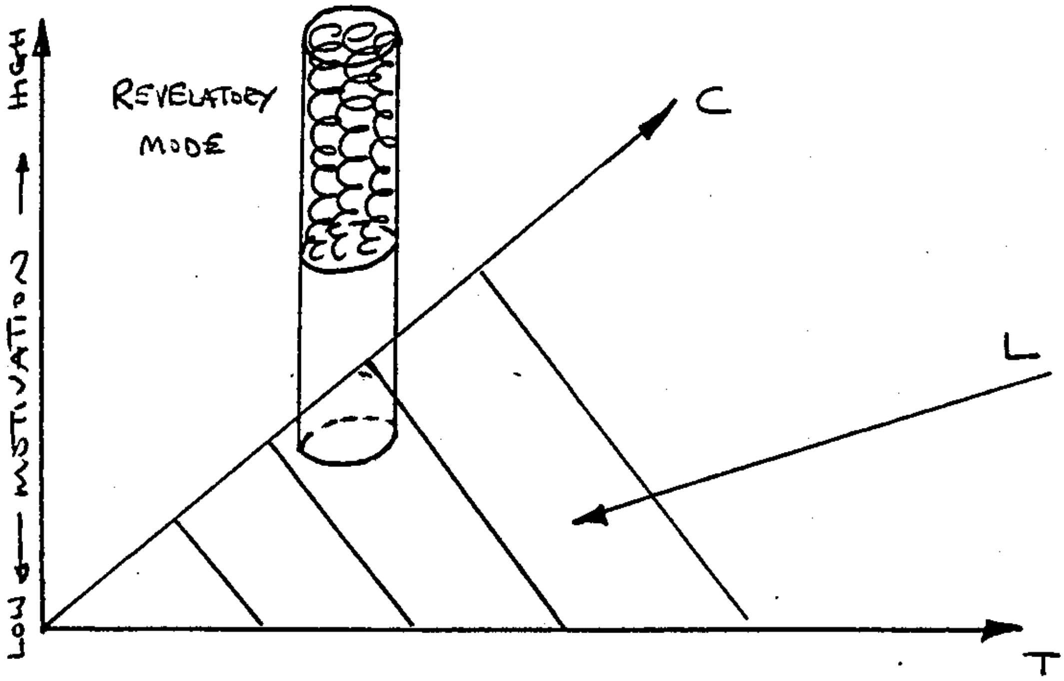


FIGURE 6.23 - ANALOGUE SOFTWARE LEVEL OF MOTIVATION

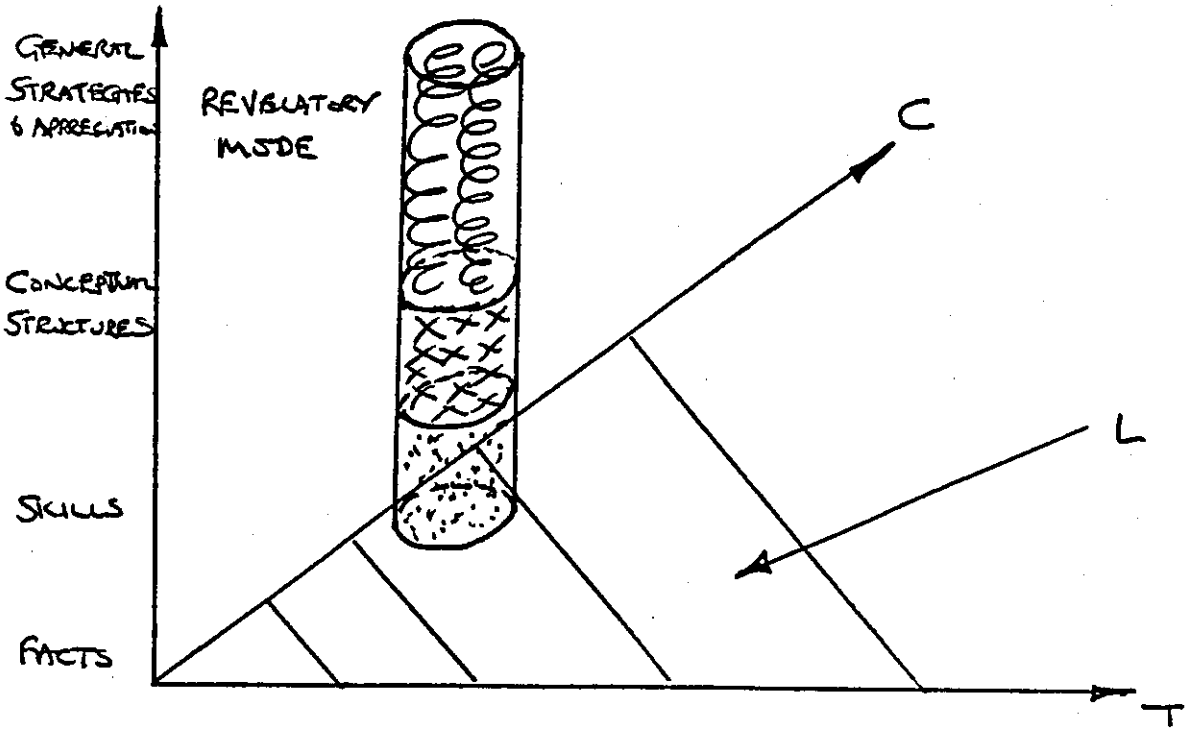


FIGURE 6.24 - ANALOGUE SOFTWARE LEVEL OF TECHNICAL COMPETENCE

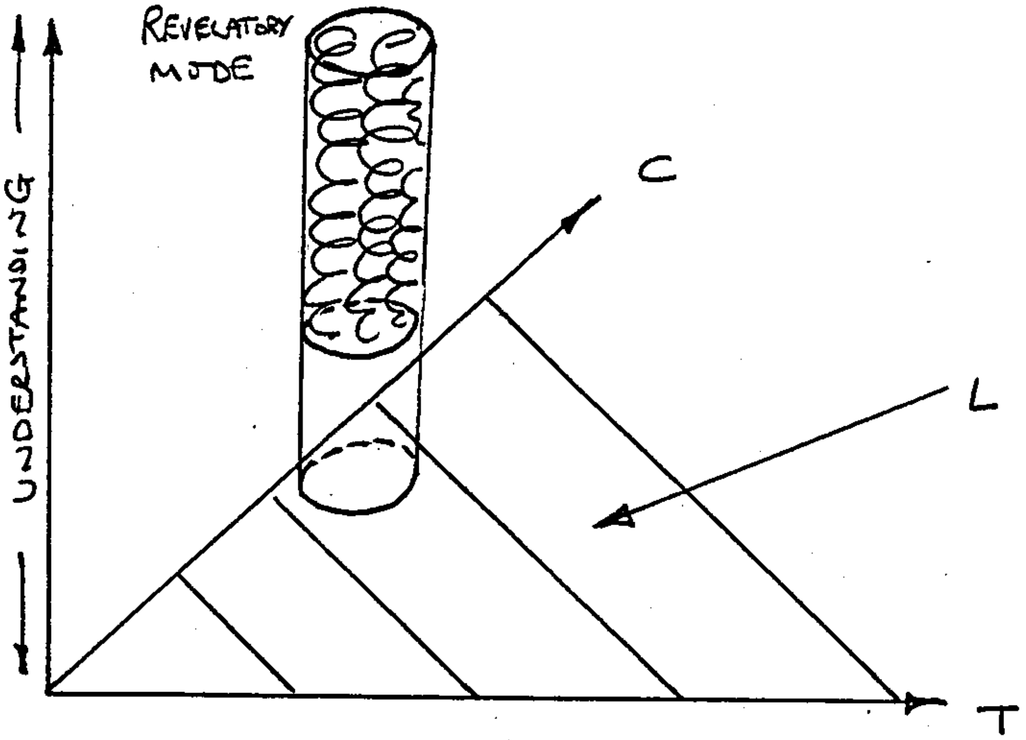


FIGURE 6.25 - DIGITAL SOFTWARE LEVEL OF UNDERSTANDING

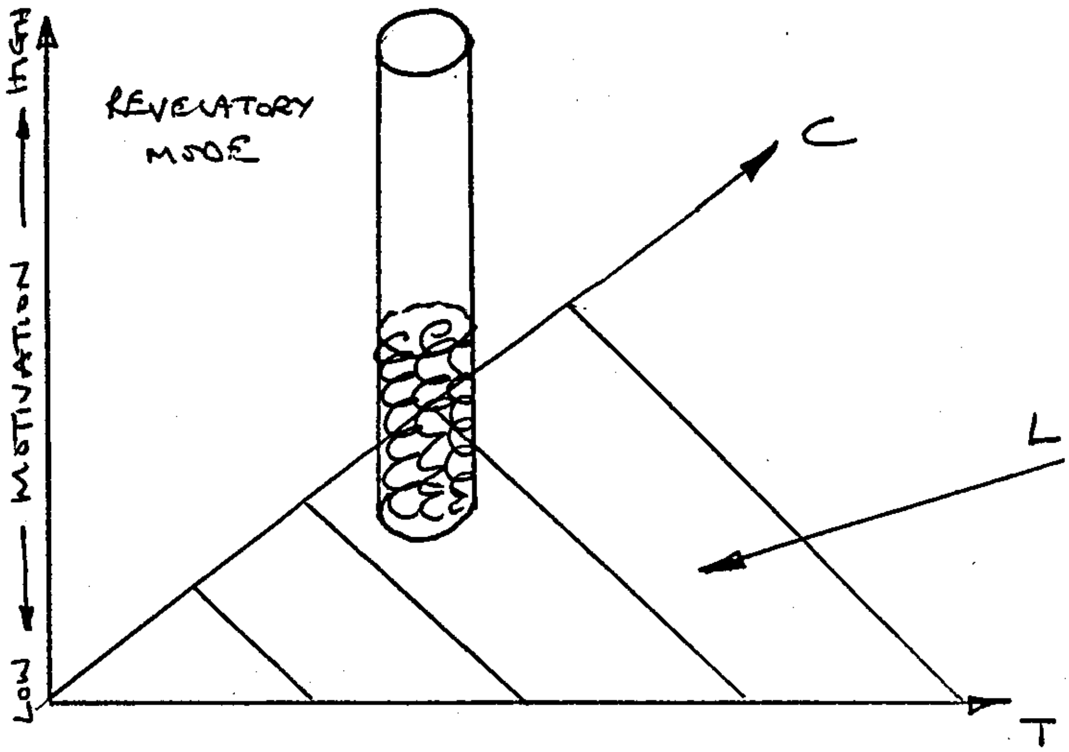


FIGURE 6.26 - DIGITAL SOFTWARE LEVEL OF MOTIVATION

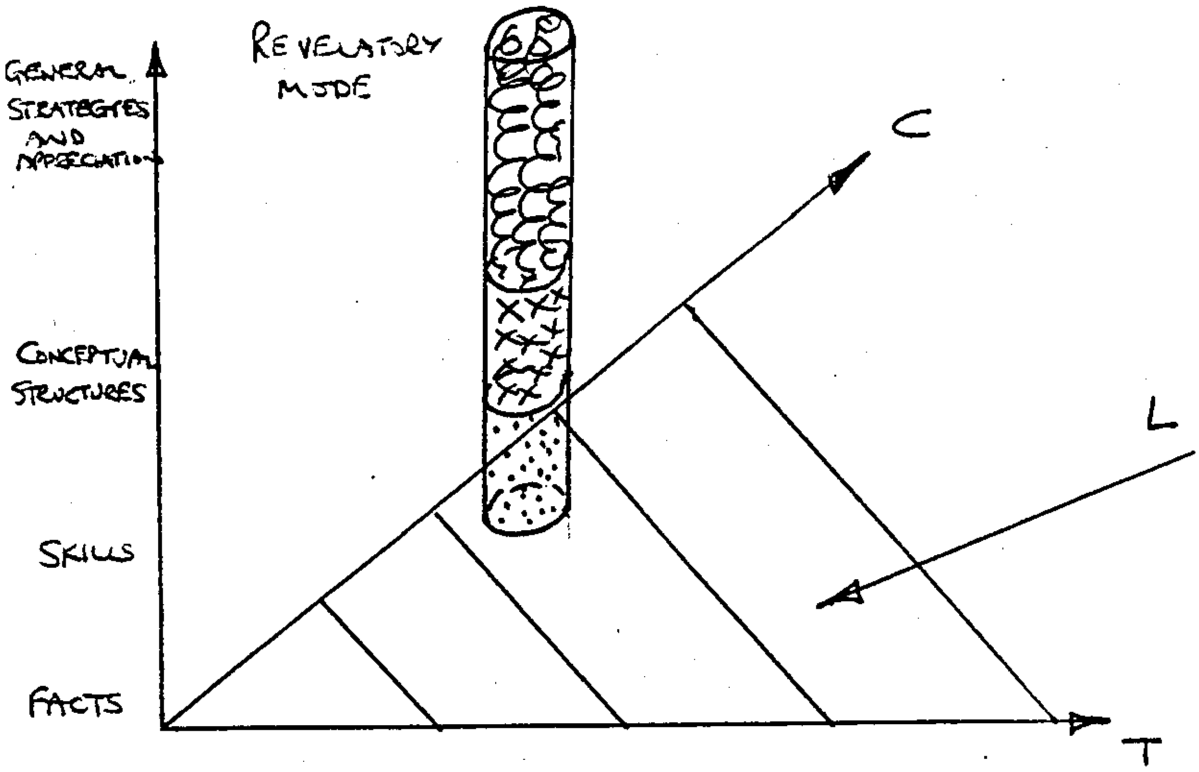


FIGURE 6.27 - DIGITAL SOFTWARE LEVEL OF TECHNICAL COMPETENCE

Similar techniques to those used in Case Study 1 were used to develop the profiles along with the detailed comments from students and lecturers outlined in the preceding paragraph.

The profiles clearly highlight the greater motivational qualities of the op-amp package and illustrate the way in which one can easily distinguish the quality of a package using such profiles.

6.3.4 SUMMARY

The above research investigations have attempted to paint a picture of the present state of development of CAL within the context of the curriculum changes that have taken place in recent years. Also the intention has been to obtain ideas of the way future developments can build on the present trends, needs and aspirations of further education lecturers to make CAL a valuable and useful tool for classroom use. Some of the viewpoints and observations collected in this research are discussed in detail in the final conclusions to this work in Chapter 7.

CHAPTER 7

CONCLUSIONS

From the use of the curriculum models to analyse the changes that have resulted in technician courses in Electrical and Electronic Engineering there appears to be an emphasis on the student being responsible for his/her own learning. This appears to tie in with the philosophies of TVEI and CPVE schemes currently in operation (see Chapter 2) and the future progressions in the National Curriculum. Clearly there is a swing away from the more traditional approaches towards a Student Centred Learning approach. This is evident from the survey results. With the Teaching and Learning Styles discussed it was apparent that there is a need for flexibility in the use of resources and the application of a particular teaching/learning style in order to optimise the maximum benefit from the learning process for the student. CAL looms as large as life as natural teaching resource within the student centred framework, which appears to becoming the main delivery strategy for teaching.

The ramifications for CAL development are clear. It must offer the same flexibility as the above curriculum changes are requiring of the teacher/lecturer. In order to do this it must take into account the various teaching strategies and attempt to match the varying learning strategies of the student.

This approach presents a tall order to the courseware developer. The salvation may lie in the application of learning models discussed in Chapters 3 and 5 to help us understand the effect a particular type/mode of CAL has in the learning environment and in particular the use of the classification profile described in Chapter 5 for evaluating the effectiveness of CAL and posing questions to the developer which lead to more flexible courseware packages. Its use has been highlighted in the evaluation of the software used in the case studies discussed in Chapter 6. The motivational and knowledge acquisition properties are clearly shown. Questions are posed such as do we need certain basic skills before acquiring the higher cognitive levels of learning. By the selection of suitable axes the designer of courseware can establish areas of weakness in the software package, above all how much control the learner will have compared to the computer and the teacher/lecturer including variations in the environment. This approach to evaluation should help in the 'fine tuning' of the software package and may lead to more 'content free' software being of a generic nature as was highlighted in the survey. Undoubtedly this will mean a greater life span for the package and offer flexibility.

What of the medium through which the program is developed, the programming language. From the survey it was clear that of the high level programming languages used for such a purpose, BASIC was by far the most widely used and hence, if staff were to write the programs, as a matter of necessity they would be in this language. However it is a language heavily criticised by professional programmers and computer educationalists alike for its limiting qualities. None more so than Self (1984) who describes it as follows :

> 'Patently unsuitable for writing computer assisted learning programs'.

This would appear harsh since it has been shown in Chapter 5 the availability of a number of software packages, written mainly in Basic. From the survey the results showed that the majority of lecturing staff felt that the software used was at least adequate. However there is a need for greater amounts of software related directly to the BTEC programmes. A major stumbling block to this in the past has been the relatively high cost of developing software. The use of the fast emerging authoring languages which appear easier to use than the typical high level languages should provide a vehicle by which staff may be able to develop effective courseware at less cost.

The above point raises the questions of effective staff training particularly involving the younger staff, who are very often the most receptive to new ideas. This was highlighted in Chapter 6 by the general comments from the survey. This is perhaps a channel for senior management to follow in order to generate effective approaches to CAL development.

In the case of the types and modes of software the survey clearly highlighted a major use of software packages utilising the computer as a tool or to run simulation type packages. This indicates the major modes as being the emancipatory and revelatory modes. In both of these there is a greater tendency towards learner control as shown in the case study evaluation results of Chapter 6. It is not to say however that Tutorial or Drill and Practice types of software package have no place. What it indicates is that perhaps there are none available of the correct quality and suitability. If nothing else the evaluations using classification profiles, have shown us that it is the motivational, learner controllability and knowledge acquisition characteristics that make it attractive to the student as an effective learning medium. It is not the mode but the quality and suitability that is important. Nonetheless these indications should be heeded in producing a range of suitable CAL courseware packages in the initial stages.

From an hardware point there is some indication from the survey that the trend is a gradual increase in the use of IBM compatibles in the Electrical and Electronic Engineering departments. This can only bode well for software development if there is only one main type of computer configuration or system and also being compatible with industrial use, i.e. keeping pace with what's going on in industry.

Overall there was an enthusiasm by lecturers and students alike in using CAL courseware if it was of good quality and applicable. The basic foundations are there for a natural developmental progression in the use of CAL, with the new National Vocational Qualifications, see NCVQ (1989) for details, likely to ensure a compatibility of BTEC courses across the country in the various specialist areas, creating a large potential market for CAL software which may reduce costs and make CAL a more marketable commodity.

The introduction of the Education Reform Act see DES (1988) which has effectively made colleges self governing has as Pratley (1988) stated caused:

> 'resource allocation to intrude upon the curriculum process model'

This has changed the FEU model illustrated in Figure 2.4 in Appendix 2 and described in Chapter 2 to that shown in Figure 7.1 Appendix 7. The clear implication of this situation is that resources are vital to the effective implementation of the curriculum. Hopefully resources in FE and in particular in Electrical and Electronic Engineering, follow the successful curriculum implementations of BTEC, and create a system whereby resources which certainly include CAL are provided to ensure effective curriculum design, implementation and evaluation. By such means then our educational aims may be finally achieved. If the authors own college is anything to go by, there is in progress the setting up of a college wide resource centre including CAL and Interactive Video etc. Hopefully this is a step in the right direction.

That is not to say however within the survey carried out there were not distractors. There were general comments made in the survey and highlighted in Chapter 6 which caste shadows on the validity and effectiveness of CAL. This and the fact that the responses from some colleges to the survey was negative having undertones of a certain amount of unrest due in part to the college and national restructuring which has and is taking place added balance to the argument that not everything in the garden is roses.

Nonetheless the point was made earlier that there is hope for the future development of CAL. To use the phrase quoted on Central (1990):

> 'A ship is safe in the harbour, but that is not what it was built for.'

Learning and the processes of acquiring it were not meant to be static, but need exploring to ensure that students and teachers/lecturers alike get the best out of the education system.

In summary it would be fair to say that the investigations undertaken in this work have given an insight into the effects of curriculum changes on CAL and its possible future progression. However, it must be said that a much larger survey is needed and more case studies undertaken to give a real picture rather than merely an insight.

BIBLIOGRAPHY AND REFERENCES

Abt, C. C. (1968), "Games for Learning." In S. S. Boocock and E. O. Schild (Eds), Simulation Games in Learning. Sage Publications: Beverley Hills C. A.

Adelman, C. and Walker, R. (1980), Developing pictures for - other frames: action research and case study, in G. Ghanan and S. Delamout (Eds), Frontiers of Classroom Research, NFER, Windsor.

Alderson, G and Blake, B. (1986), TFORM; The Design and Development of a Computer Aided Learning Package, In the Application of Microcomputers to Mathematics and Science Teaching, (ed Johnson, D. C.). UNESCO Pilot Project U.K. Report No.2.

Alessi, S.M and Trollip, S.R. (1985), COMPUTER BASED INSTRUCTION/Methods and Developments, Prentice Hall: Englewoods Cliffs, N.J.

Alvey Committee (1982) Programme for Advanced Information Technology. The Alvey Report, H.M.S.O. LONDON.

Anderson, J.R. and Bower, G. H. (1973) Human associative memory: V. H. Winston. Washington D. C.

Anderson, J. S. A. (1985), 'Can information technology change the curriculum?' In Alloway, B. S. and Mills, G. M. (Eds) (1985), Aspects of Educational Technology XVIII. New Directions in Education and Training Technology. Kogan Page : London.

Armstrong, P.K., Wiseman, A. N., and Bajpai, A. C. (1989), Using classification profiles to question the development and use of CAL in mathematics, Journal of Computer Assisted Learning 5, 132-144.

Atkin (1975), An Introduction to Curriculum Research and Development by L. Stenhouse Ch6, p26. Heinmann.

Atkinson, R. C. and Stuffurin, R. M. (1968), Human memory: A proposed system and its control processes in K. W. Spence and J. T. Spence (Eds), The pyschology of learning and motivation Vol 2 Academic Press 1968, New York.

Ausubel, D.P. (1968), Educational Psychology: A Cognitive View, Holt Rinehart and Winston, New York.

Ausubel, D. P., Novak, J. S. and Hanesian, H. (1978), Educational Psychology: a Cognitive View, (2nd Edition), Holt Rinehart and Winston, New York.

Bailey, K. D. (1978), Methods of Social Research, Collier - Macmillan, London.

Bandura, A. (1977), Social Learning Theory, Prentice-Hall, Englewood Cliffs, N.J.

Barker, P. G. (1979), The computer as an audio-visual resource, Computers and Education 3, 23-34.

Barker, P. G. (1984), Computers as an educational resoruce, Analytical Proceedings of the Chemical Society, 21(4), 140-142.

Barker, P. G. and Yeates, H. (1985), Introducing Computer Assisted Learning, Prentice/Hall International.

Barker, P. G. (1987) Author Languages for CAL; Macmillan, London.

Bartlett, F. C. (1932), Remembering, Cambridge University Press, London.

Bennett, N. (1976), Teaching Styles and Pupil Progress. Open Books, London.

Bell R. (1972), Education in Great Britain and Northern Ireland p.186.

Bennis, W. G., Benne, K. D. and Chin, R. (1969), The Planning of Change, 2nd Edition. Holt Reinhart and Winston, New York.

Biggs, J. B. (1976), Dimensions of Study Behaviour: another look at ATI, Br. J. educ. Psychol., 46, 68-80.

Bitzer, D. L. (1976), The Wide World of computer based education, Advances in Computers, 15, 239-283.

Bitzer, D. L., Braunfield, P. G. and Lichtenberger, W. W. (1962), PLATO II: A multiple-student, computer controlled automatic teaching device, in Programmed learning and Computer Based Instruction, Proceedings of the Conference on Applications of Digitial Computers to Automated Instruction, October 10-12, 1961, 205-216, Jophn Wiley, NEW YORK.

Bloom, B. S. (1964), see Krathwoht, D. et al (1964), Taxonomy of Educational Objectives: Handbook II: Affective Domain, Longmans, London.

Boden, M. A. (1981), Minds and Mechanisms, Harvester, Brighton.

Bolam, R (1976), The management of educational change: towards a conceptual framework. In Houghton, V. et al (Eds) (1976). Management of Organisations and Individuals. Ward Lock, London.

Braun, L. (1981), Computer-aided learning and the microcomputer revolution, Programmed Learning and Educational Technology, 18 p.p. 223-229.

Briggs, J. (1984). In 'The Theoretical Influences on the Design and Implementation of Computer Mediated Learning.'

D. F. Sewell, R. D. Ward and D. Rotheray, In Aspects of Educational Technology XVIII, New Directions in Education and Training Technology. Edited by B. A. Alloway and G. M. Mills Kogan Page, London.

Brown, J. S. and Burton, P. R. (1974), 'SOPHIE - a pragmatic use of artificial intelligence' in CAI, Proceedings of the 1974 Annual National Conference of A.C.M.

Brown, M. (1980), PRESTEL and Education II: A viewdata telesoftware system for education in Proceedings of the 4th International Online Information Meeting, 115-118, Learned Information, London.

Bruner, J. (1973), Beyond the Information Given Norton: New York.

BTEC (1986), Documents on new philosophy of BTEC; 'Assignments Help to Learn' ; Common Skills and Core Themes General Guidelines, BTEC : London.

Bunderson, C. V. and Dunham, J. L. (1968), The University of Texas, Computer Assisted Instruction Laboratory, University of Texas, Austin.

Cantor, L.and Roberts, I.F. (1972), Further Education in England and Wales, 2nd Edition, Routledge and Kegan Paul : London.

Cattell, R. B. (1940), A Culture free Intelligence Test. Journal of Educational Psychology V.31, p.p. 161-179.

Carbonell, J. R. (1970), AI in CAI: an artificial intelligence approach to computer assisted instruction. IEEE. Transactions on Man-machine systems MMS-11 (4) 181-189, 190-202.

CENTRAL (1990),'Highway' Programme on Sunday 14th January.

CET (1982), User Specifications (USPEC'S) News Sheet, Council for Educational Technology, London.

Chandler, D. (1984), Young Learners and the Microcomputer. Open University Press, Milton Keynes.

Chin, R. (1968), Basic Strategies and procedures in affecting change. In Morphet, E. L. and Ryan, C. O. (1968) Designing Education for the Future, No. 3, Citation Press; New York.

Clancy, W. J. (1979), Tutoring rules for guiding a case method dialogue, International Journal of Man-Machine Studies, 11, 25-49.

Clocksin, W. and Mellish, C. (1981), Programming in PROLOG, Springer-Verlag: New York.

Coburn, P., Kelman, P., Roberts, N., Snyder, T., Watt, D. and Weiner, C. (1982), Practical Guide to Computers in Education, Addison-Wesley.

Coffey, J. (1978), Development of An Open Learning System in Further Education, Working Paper 15, Council for Educational Technology, London.

Cohen, L. and Mannion, L. (1980), Research Methods in Education 2nd Ed. Croom Helm, Beckenham.

Craik, K. (1948), Theory of the Human Operator in Control Systems. British Journal of Psychology V38 pp 56-61 and pp 142-148.

Cronbach, L. J. (1957), The two disciplines of scientific psychology, Amer Psychol; 12, 671-684.

Crowder, N. A. (1959), 'Automatic tutoring by means of instrinsic programming in E. Galanter (ed), Automatic Teaching: the State of the Art, Wiley, New York.

Curzon, L. B. (1985), Teaching in Further Education, An outline of Principles and Practice', 3rd Edition: Cassell, London.

Dahlgren, L. O. and Marton, F. (1978), Student's conceptions of subject matter: an aspect of learning and teaching in higher education studies in Higher Educ., 3 25-35.

Dalin, P. (1976), Strategies of innovations. Extracted from Case Studies in Educational Innovation: IV Paris, OECD/CERT, pp 44-51, cited in Open University (1976), Innovations: Problems and Possibilites Course E203.

Day, H. I. and Berlyn, D. E. (1971), Instrinsic Motivation. In Psychology and Educational Practice (ed. G. Lesser) Scott Foresman, Glenview, Illionois. Duchastel, S., Doublait, S. and Iurbean, J. (1988), Instructable Instructional Artifical Intelligence In Journal of Information Technology Vol 3 No.3.

Davies, I.(1969), Education and Social Science, New Society, May 8. See also Hoare, Q,. (1967). Education: programmes or men, New Left Review, 32.

Denzin, K. D. (1970), The Research Act in Sociology: A Theorectical Introduction to Sociological Methods, Butterworth Group; London.

DES (1969), National Advisory Council for Industry and Commerce: REport of the Committe on Technician Courses and Examinations. Chairperson: H. L. Haslegrave, H.M.S.O: London.

DES (1982) Committee of Inquiry into the Teaching of Mathematics, Mathematics Counts. (The Cockcroft Report) H.M.S.O. London.

DES (1984), Education Supports Grants: Circular No.6/84 H.M.S.O., London.

DES (1985), The curriculum from 5 to 16, Curriculum Matters 2 H.M.S.O., London.

DES (1988) Local Management of Further Education Colleges: Delegation Schemes and Articles of Government (Draft), DES April 1988.

DES (1989), Information Technology from 5 to 16 Curriculum Matters 15 H.M.S. O. London.

Donaldson, M. (1978), Children's Minds: Fontana Collins, Glasgow.

Ellington, H., Adinall, E. and Percival, F (1982), A Handbook of Game Design, Kogan Page: London.

Elliot, P. W. (1989), 'What is TVEI?' Walsall College of Technology Technical and Vocational Education Initiative (TVEI).

Entwistle, N. (1981), Styles of Learning and Teaching, John Wiley and Sons Ltd.

Evans, S. H. (1967), A Brief Statement of Schema Theory, Psychonomic Science 8, 87-88.

FEU (1981), CURRICULUM CHANGE: An Evaluation of TEC programmes development in colleges FEU, London.

FEU (1983), Computer Literacy: Part I - A Managers Guide. F.E.U. London.FEU (1984), Design of Microelectronic Programmes - A Consultative Document Further Education Unit: London.

FEU (1985)a), FIFTH GNERATION COMPUTERS, Their Implications for further education. Further Education Unit: Silverdale Press.

FEU (1985)b) COMPUTER BASED LEARNING IN F.E.:'A staff development model': F.E.U. London.

FEU (1986), Strategy and Processes, Document: FEU, London.

FEU (1987), Annual REport and Accounts 1986-87, Silverdale Press.

FEU (1988), Further Education Unit Newsheet, Supporting Further and Higher Education: FEU Publications, London.

FEU (1989), Newsletter: Summer 89, FEU, London.

Fothergill, R (1981), The Microelectronics Education Programme - a strategy, Deprtment of Education and Science, London.

Gable, A., and Page, C (1980), 'The use of artifical techniques in Computer Assisted Instruction: and overview', International Journal of Man-Machine Studies 12, 259-282.

Gagne, R. M. (1970, 1975), The Conditions of Learning, Holt Rinehar and Winston; London (1970): Essentials of Learning for Instruction Dryden Press HInsdale (1975).

Gagne, R. M. (1977), The Conditions of Learning, 3rd Edition, Holt Reinhar and Winston.

Gagne, R., and Briggs, L. J., (1979), Principles of Instructional Design, Holt Reinhart and Winston.

Gagne, R. M., Wagner, W. and Rojas, A (1984), Planning and authoring computer assisted instruction lessons. Educational Technology 21, 17-26.

Gagne, R.M. (1983), The Conditions of Learning, Holt - Saunders.

Galperian, P. Y. (1965), Psychology and Teaching, USSR Publishing House. Greeno, J. G., and Bjork, R. A., Mathematical learning theory and the new "mental foresty", Annual Review of Psychology 24, 81-116

Goldenberg, A. and Ross, J. (1981), Is the Smalltalk - 80 system for children, Byte, 8, 6, 347-68.

Goldenburg, E. P. (1982), LOGO - a cultural glossary, Byte 7, 8, pp 163-193.

Gronlund, N. E. (1978), Stating Objectives for Classroom Instruction, Macmillan.

Guilford, J. P. (1950), Creativity, Amer. Pscyhol, 5, 444-454.

Gustafsson, J. E. (1976), Verbal and Figural Aptitudes in Relation to Instructional Methods, Acta Universtatis Gothoburgenis, Gothenburg.

Hannon, P. and Wooler, S. (1985), Psychology and Educational Computing, UNIT 10 in Children,Computers and the Curriculum by J.J. Wellington, Harper Education Series; Harper Row : London.

Hawkridge, D. (1983), New Information Technology in Education, Croom Helm.

Heath, R. (1964), The Reasonable Adventurer, University of Pittsburg Press, Pittsburg.

Heath, R (1978), Personality and the Development of Students in Higher Education in Parker, C. A. (Ed), Encouraging Development in College Students, University of Minnesota Press, Minneapolis.

Hebb, D. O. (1949), The Organisation of Behaviour, Wiley, New York.

Hick, W. E. and Bates, J. A. V. (1950), The Human Operator of Control Mechanisms, Permanet Records of Research and Development No. 17 Ministry of Supply, H.M.S.O., London.

Hirst, P. H. (1965), Liberal Education and Nature of Knowledge 113-118 in Archainbault.

H.M.I. (1984), Report on 16-19 provision, H.M.S.O. LONDON.

H.M.S.O. (1986) Government White Paper 'Working Together - Education and Training', H.M.S.O., London.

Honey, P. and Mumford, A. (1989) 'Trials and Tribulations' in Education Guardian December 19th 1989.

Hooper, R. and Toye, I (1975), Computer Assisted Learning in the United Kingdon: Some Case Studies, Council For Educational Technology: London.

Hooper, R. (1975), Introduction and overview, in R. Hooper and I. Toye (eds), Computer Assisted Learning in the United Kingdom - Some Case Studies, Council for Educational Technology on behalf of the National Development Programme in Computer Assisted Learning, London.

Hoyle, E. (1969),. How does the curriculm change? Journal of Curriculum Studies, Vol 1, No. 3, p 236.

Hoyles, C. and Sutherland, R (1987), Ways of Learning in a computer based environment: some findings of the LOGO maths project. Journal of Computer Assisted Learning 3(2), 67-80.

Howe, J. A. and Du Boulay, B. (1979), Microprocessor Assisted Learning: Turning the Clock Back? Programmed Learning and Educational Technology, V16, No. 3, pp 240-246.

Hudson, L. (1966), Contrary Imaginations, Methuen: London.

Hudson, L. (1970), Frames of Mind, Penguin: London.

Illich, I. (1971), Deschooling Society, Harper and Row.

Kagan, J., Rosman, B. L., Day, D., Alber, J. and Phillips, N. (1964), Information processing in the child: significance of analytic and reflective attitudes, Psychol. Monogr., 78 (Whole).

Kagan, J. (1966), Modifiability of an Impulsive Tempo, in J. Educ. Psychol., 57, pp 359-365.

Kay, A. and Goldberg, A. (1977), Personal dynamic media, Computer, 10, 31-41.

Kemmis, S., Atkin, R., and Wright, E. (1977), How Do Students Learn?; Centre for Applied Research in Education, University of East Anglia.

Kerr, J. (1968), The problem of curriculum reform, In: Kerr, J. (Ed) Changing the Curriculum 13-38, ULP: London.

Kimble, D. P. (1963), Physiological Psychology, Addison-Wesley.

Klausmeir, H. J. and Fieldman, K. V. (1975), Effects of a Definition and a Varying Number of Examples and Non Examples on Concept Attainment, Journal of Educational Psychology, 67, (1975), 174-78.

Kogan, N. (1976), Cognitive Styles in Infancy and Early Childhood; Lawrence Erlbaum, Hillsdale, New Jersey.

Kogan, M. (1978), The Politics of Educational Change, Manchester, Manchester University Press p100.

Koran, M. L. 1971), Differential Response to Inductive and Deductive Instructional Procedures. 'Journal of Educational Psychology' 62, 300-307.

Laurillard, D. (1979), 'The processes of student learning' in special issue of Higher Education, Vol 8, 1979, p.p. 395-409.

Lawton, D. (1983), Curriculum Studies and Educational Planning, Hodder and Stoughton.

Leith, G. O. M. (1974), Individual Differences in Learning Interactions of Personality and Teaching Methods, In Personality and Academic Progress, Association of Educational Psychologists, London.

Lewis, P. (1989), "Spend, Spend, Spend!", Computer/IT p. B23: The Times Educational Supplement 10.3.89.

Linn, P. (1985), Mircocomputers in education: 'living and dead labour' in Solomonides, T. and Levidow, L. (eds) Compulsive Tehcnology: computers as culture, pp 58-101, Free Association Books.

Maddison, J. (1983), Education in the Microelectronics Era, Open University Press: Milton Keynes.

Marton, F (1975), 'What does it take to learn? in How Students Learn, N. Entwistle and D. Hounsell (eds) (1975), University of Lancaster, Institute for Post Compulsory Education, Lancaster.

Marton, F. and Saljo, R. (1976), 'On qualitative differences in learning 1. Process and Outcome', British Journal of Psychology, Vol 46, pp 4-11.

McLeish, J. (1968), The Lecture Method, Cambridge Monographs on Teaching Methods I. Cambridge Institute of Education, Cambridge, UK.

Merrill, M. D. (1980) Learner control in Computer Based Learning, Computers and Education, 4, 77-95, 1980.

Messer, S. (1976), Reflection - Impulsivity: a review, Psychol. Bull. k, 83, 1026-1052.

MESU (1987), Microelectronic Support Unit brochure, Published by MESU 1987.

Mills, G. M. (1984), Categories of Educational Microcomputer Programs, Theories of Learning and Implications for Future Research: Paper presented at ETIC '84 Conference Bradford University.

National Curriculum Council (1989), National Curriculum Council, Consultation Report, Technology 5-16, In the National Curriculum, NCC, YORK.

NCET (1989) Annual Report 1988, National Council for Educational Technology.

NCVQ (1986), Series 2 Pamphlet , NCVQ, London.

NCVQ (1989), National Vocational Qualifications: Criteria and Procedures, NCVQ, LONDON.

Norman, D. A. and Runelhart, D. E. (1975), Memory and Knowledge. In Norman, D. A. et al, Explorations in Cognition W. H. Freeman: San Francisco.

Norman, D. A. (1982), Learning and Memory, W. H. Freeman: San Francisco.

O'Shea, T. (1979), Self-Improving Teaching Systems: an Application of Artificial Intelligence to Computer Assisted Instruction, Burkhauser - Verlag, Basel.

O'Shea, T. and Self, J. (1983), Learning and Teaching with Computer, Harvester Press, Brighton.

Papert, S. (1973), Uses of technology to enhance education, AI memo No. 298, MIT, Cambridge; Mass.

Papert, S. (1980), Mindstorms: Children Computers and Powerful Idea, Basic Books: New York.

Papert, S. (1972), Teaching Children to be Matehmaticians, International Journal of Mathematics Education and Science and Technology, 3, 249-62.

Pask, G (1976),Styles and Strategies of learning, British Journal of Psychology, Vol 46, pp 1128-48.

Percival, F. and Ellington, H. (1984), A Handbook of Educational TEchnology, Kogan Page.

Perry, W. G. (1970), Forms of Intellectual and Ethical Development in the College Years, Holt Rinehart and Winston.

Peters, M. (1987), Paper on Student Centred Learning for Conference on Teaching/Learning Strategies, Walsall College of Technology, June 1987.

Peters, R. S. (1965), See Hirst P. H. (1965).

Pogne, R. E. (1980), The Authoring System: interface between author and computer, Journal of Research and Development in Education 14(1), 57-68.

Popham, W. J. et al (Eds) (1969), Objectives and Instruction, in Instructional Objectives, AERA:/Rand McNally, Chicago.

Postman, N. and Weingartner, C. (1969), Teaching as a Subversive Activity, Delacorte, New York.

Povenmuire, K. and Roscoe, S. N. (1973), The Incremental Transfer Effectiveness of a Ground Based Aviation Trainer, Human Factors 15, 534-42.

Powney, J. and Watts, (1987), Interviewing in Educational Research, Routledge : London.

Pratley (1988), Planning the FE CURRICULUM: Implications of the 1988 Education Reform Act: Perspectives for Administrators and Managers, FEU: York.

Rath, G. J. (1959), The IBM Research Centre Teaching Machine Project, in Automatic Teaching - State of the ARt, edited by E. Galcunta, John Wiley, New York.

Radatz, H. (1979), 'Some Aspects of Individual Differences in Mathematics Education,' JRes Math ED, 10, 359-63.

Robertson, I. T. (1977), An investigation of some relationships between learning and personality, Unpublished Ph.D., Open University, Milton Keynes.

Rogers, C. (1965), Clinet-Centred Therapy, Houghton Mifflin C., Boston.

Roscoe, S. N. (1971), Incremental Transfer Effectiveness, Human Factors 5, 34-42.

Roscoe, S. N. (1972), A Little More on Incremental Transfer Effectiveness, Human Factors 14, 363-64.

Roshine, B. (1983), 'Teaching Functions in Instructional ?Programs,' Elementary School Journal, 83 (4) 335-51.

Rubin L. (Ed), Curriculum, Handbook: the Disciplines, Current Movements and Instructional Methodology, 605-13 Boston: Allyn and Bacon.

Rumblehart, D. E., Lindsay, P. H. and Norman, D. A. (1972), A process model for long-term memory In E Tutoring and W. Donaldson (Eds), Organisation of memory, Academic Press, New York.

Rushby, N. J. (1979), An Introduction to Educational Computing, Groom Helm, London.

Ryle, G. (1983), The Concept of Mind, Penguin.

Schank, R. C. (1982), Dynamic Memory, Cambridge University Press.

Schild, E. O. (1968), 'The Shaping of Strategies,' In S. S. Boocock and E. O. Schild (Eds), Simulation Games in Learning, Sage Publications; Beverley Hills; CA.

Scrimshaw, P (1983), Educational Ideologies, Unit 2, E204, Purpose and Planning in the Curriculum OUP, Milton Keynes.

Self, J. (1984), Microcomputers and Education, A Critical Appraisal of Education Software, Harvester Press.

Siklossy, (1970), Computer Tutors that know what they teach, in Proceedings of the Fall Joint Computer Conference, Volume 37, Houston, Texas.

Skilbeck, M. (1976), The curriculum development process: a model for school use, In MacMahon, J. Styles of Curriculum Development, Unit 8, E203, Curriculum Design and Development, Open University Press, Milton Keynes.

Skinner, B. F. (1961), Why we need teaching machines, Harvard Educational Review, No. 3, 1961.

Skinner, B. F. (1968), The technology of teaching, Appleton-Century-Crofts.

Smith, K. (1966), Cybernetic Principles of Learning and Educational Design, Holt, Rinehart and Winston.

Snow, R. E. (1976), Aptitude-treatment interactions and individual alternatives in higher education. In Messick, S. (Ed), Individuality in Learning, Josey-Bass, San Franciso.

Stenhouse, L. (1975), An Introduction to Curriculum Research and Development, Heinmann, London.

Stenhouse, L. (1985), An Introduction to Curriculum Studies 2nd Edition P. H. Taylor and C. M. Richards.

Taba, H. (1962), Curriculum Development: Theory and Practice, Harcourt, Brace and World, New York.

Taylor, P. H. and C. M. Richards (1985), An Introduction to Curriculm Studies, 2nd Edition, NFER-NELSON, Publishing Co. Ltd.

TEC (1975), TEC Circular 6/75.

TEC (1976), TEC Guidance Note No.1.

Tyler, R. (1949), Basic Principles of Curriculum and Instruction, University of Chicago Press, Chicago.

Thurstone, L. L. (1938), Primary mental abilites, Psychometr Monogr, No. 1.

Vincent, B. and Vincent, T (1985), Information Technology and Further Education, Kogan Page: London.

Walker, D (1988), The Interactive Video for Geography Project The CTISS FILE/7 October.

Watson, D. (1987), Developing CAL: Computers in the Curriculum, Harper Education Series: Harper and Row, London.

Wellington, J. J. (1985), Children, Computers and the Curriculum, Harper and Row, London.

Wexler, J. D. (1970), Information networks in generative computer assisted instruction, IEEE. Transactions on Man-Machine Systems, 11, (4), 190-202.

Weiner, N. (1948), Cybernetics, MIT Press.

Wheeler, D. (1967), Curriculum Process University of London Press (ULP): London.

Witkin, H. A. (1976), Cognitive Style in academic performance and in teacher-student relations, In Messick, S. (Ed), Individuality in Learning, Jossey-Bass, San Francisco.

Witkin, H. A. Morre, C. A. Goodenough, D. R. and Cox, P. W. (1977), Field-Dependent and Field Dependent Cognitive Styles and their Educational Implications Rev. Educ Res; 1-64.

Wright, B. and Dillon, P (1988), 'The Use of Interactive Video in Initial Teacher Training,' Discussion Paper, Exeter University.

Wright, B. (1988), 'Does Domesday have a place in the Mathematics Classroom?, article from Teaching Mathematics and its Applications Volume 7, No. 2.

Young, M. (1970), Innovations and Research in Education, Routledge and Kegan Paul, London.

APPENDIX 1

Approach	*Distinguishing characteristics*	*Illustration*
Linear programs	Derivation from behaviourism; systematic presentation; reinforcement and self-pacing.	Last (1979)
Branching programs	Corrective feedback: adaptive to student response; tutorial dialogues; use of author languages.	Ayscough (1977)
Generative computer-assisted learning	Drill-and-practice; use of task difficulty measures; answering student questions.	Palmer and Oldehoeft (1975)
Mathematical models of learning	Use of statistical learning theories of limited applicability; response-sensitivity.	Laubsch and Chiang (1974)
TICCIT	Team production of courseware: 'mainline' lessons; use of television and minicomputers; learner control.	Mitre Corporation (1976)
PLATO	Multi-terminal interactive system; visual displays; 'open shop' approach; concern over cost.	Bitzer (1976)
Simulation	Computer as laboratory; interactive graphics: typically small programs.	McKenzie (1977)
Games	Intrinsically motivating; audio-visual effects; often lacking educational aims.	Malone (1980)
Problem-solving	Computer as milieu; programming by children; derivation from Piaget's theory and artificial intelligence.	Papert (1973)
Emancipatory modes	Computer as labour-saving device; task-oriented; use of microcomputers and public information systems.	Lewis and Tagg (1981)
Dialogue systems	Tutorial strategies; use of natural language; mixed initiative; use of complex knowledge representations.	Carbonell (1970)

TABLE 1.1 - APPROACHES TO CAL IN THE 1970's

6. Children acquire the conventions and values of the new 'information age' from their experiences in and out of school and through the media. They learn about the capabilities, limitations and uses of computers, as well as of their associated technologies. Although IT is only one of a host of important factors affecting society and schools today, it is unusual among current agencies of change in that it impinges directly on the learner at all ages; on the nature and content of study; and therefore on the curriculum and the teacher.

7. IT has a critical role in enhancing the learning process at all levels and across a broad range of activities including but going beyond the National Curriculum. Through the use of IT in the curriculum, schools will also be helping pupils become knowledgeable about the nature of information, comfortable with the new technology and able to exploit its potential. The aims of working with IT in schools are:

i. to enrich and extend learning throughout the curriculum, using the technology to support collaborative working, independent study and re-working of initial ideas as well as to enable pupils to work at a more demanding level by obviating some routine tasks;

ii. to help young people acquire confidence and pleasure in using IT, become familiar with some everyday applications and be able to evaluate the technology's potential and limitations;

iii. to encourage the flexibility and openness of mind necessary to adjust to, and take advantage of, the ever-quickening pace of technological change, while being alert to the ethical implications and consequences for individuals and society;

iv. to harness the power of the technology to help pupils with special educational needs or physical handicaps to increase their independence and develop their interests and abilities;

v. to help interested pupils to undertake detailed study of computing and to design IT systems for solving problems.

FIGURE 1.1 - AIMS OF I.T IN SCHOOLS

8. All pupils should use a range of IT resources in core, other foundation and, where relevant, non-foundation subjects and cross-curricular themes. In the four key stages such resources might include electronic toys, calculators and musical instruments, as well as word processors and other computer software. The examples given within the following objectives are for illustration only. Opportunities for using IT within the classroom are many and technological change continues to add to and change them. Some of the objectives themselves may need review within a short span of time.

9. The differences in the backgrounds of pupils, their interests and the level of IT provision to which they have access outside school mean that confidence and skills in using IT are not related solely to the ages of pupils. Schools must build on whatever skills pupils bring with them and give individuals opportunities to share their knowledge with others and to employ such IT as is available in school and outside to further their learning.

10. During their time at school pupils' experience with IT should enable them to acquire certain knowledge, skills and understanding. Through work required within the National Curriculum and also related to other areas they should develop the general capability:

i. to communicate ideas and information in a variety of forms using IT where appropriate (e.g. using word processing, electronic mail or desk-top publishing);

ii. to capture, store, gain access to, change and interpret information (e.g. using databases, spreadsheets or viewdata systems);

iii. to assess critically the content and presentation of information from various sources, including that in various databases (e.g. using viewdata or examples of computer-generated unsolicited personalised mail).

FIGURE 1.2 - OBJECTIVES FOR I.T 5-16

In addition they should be able:

iv. to carry out mathematical investigations or explore computer-based representations of imaginary situations or of real processes (e.g. using a simulation of an archaeological exploration or power supply network, or studying an economic model);

v. to make appropriate use of an IT system in the aesthetic activities of drawing, designing and making or composing (e.g. using an electronic music synthesiser, graphics software or a lathe controlled by a computer);

vi. to measure and control environmental variables and movement, using IT as appropriate alongside other resources (e.g. building an automatic device to count the number of times people enter a room);

vii. to consider and discuss some of the social changes and ethical considerations implicit in some uses of IT (e.g. databases containing financial information about individuals).

11. As they progress through the four key stages engaging in activities related to the above objectives pupils should acquire growing confidence and satisfaction in using IT and sensitivity to the wider implications of its use. They should develop a broad understanding of the ways in which particular systems work; familiarity with concepts associated with hardware and software; a vocabulary of terms associated with IT; and the capacity to learn from simply worded instructions how to operate unfamiliar technological devices. These aspects should be addressed within the context of mainstream curricular activities rather than in isolation.

12. The objectives are expanded on pages 9–32 to indicate the detail and depth of study appropriate to pupils in primary schools (key stages 1 and 2) and secondary schools (key stages 3 and 4). Some older secondary pupils, stimulated by their experience with IT, may wish to study a wide range of more advanced applications of computing. The last section deals with specific objectives for those pupils following specialist courses in computing or IT.

FIGURE 1.2 - (CONTINUED)

In each key stage, pupils should develop information technology capability through activities which arise in other curriculum areas. These activities, undertaken individually or in groups, should:

- develop confidence and satisfaction in the use of information technology;
- broaden pupils' understanding of the effects of the use of information technology;
- encourage the flexibility needed to take advantage of future developments in information technology;
- enable pupils to become familiar with the computer keyboard;
- encourage the development of perseverance;
- enable pupils to take greater responsibility for their own learning, and provide opportunities for them to decide when it is appropriate to use information technology in their work.

Activities should be appropriate to both boys and girls.

FIGURE 1.3 - RECOMMENDATIONS FOR PROGRAMMES OF STUDY FOR INFORMATION TECHNOLOGY CAPABILITY

APPENDIX 2

Ralph W. Tyler (1945)

1 What educational purposes should the school seek to attain?

2 What educational experiences can be provided that are likely to attain these purposes?

3 How can these educational experiences be effectively organised?

4 How can we determine whether these purposes are being attained?

Purpose ---> Experience --->Organisation ---> Evaluation

Aims and Objectives ---> Content ---> Methods --->Evaluation

The 'Tyler' model for curriculum planning.

FIGURE 2.1 - TYLER RATIONALE OBJECTIVE MODEL

Levels in the Cognitive and Affective Domains and Sample Objectives

A. Cognitive domain

Level 1 KNOWLEDGE
'To make pupils conscious of correct form and usage in speech and writing'
'Knowledge of a relatively complete formulation of the theory of evolution'

Level 2 COMPREHENSION
'Skill in translating mathematical, verbal material into symbolic statements and vice versa'
'Skill in predicting continuation of trends'

Level 3 APPLICATION
'The ability to predict the probable effect of a change in a factor on a biological situation previously at equilibrium'

Level 4 ANALYSIS
'Skill in distinguishing facts from hypotheses'

Level 5 SYNTHESIS
'Ability to tell a personal experience effectively'
'Ability to propose ways of testing hypotheses'

Level 6 EVALUATION
'The comparison of major theories, generalizations and facts about particular cultures'

B. Affective domain

Level 1 RECEIVING (ATTENDING)
'Attends carefully when others speak in direct conversation, on the telephone, in audiences'

Level 2 RESPONDING
'Finds pleasure in reading for recreation'

Level 3 VALUING
'Assumes responsibility for drawing reticent members of the group into conversation'

Level 4 ORGANIZATION
'Forms judgements as to the responsibility of society for conserving human and material resources'

Level 5 CHARACTERIZATION BY A VALUE OR VALUE-COMPLEX
'Readiness to revise judgements and to change behaviour in the light of evidence'

FIGURE 2.2 - BLOOM's TAXONOMY OF EDUCATIONAL OBJECTIVES

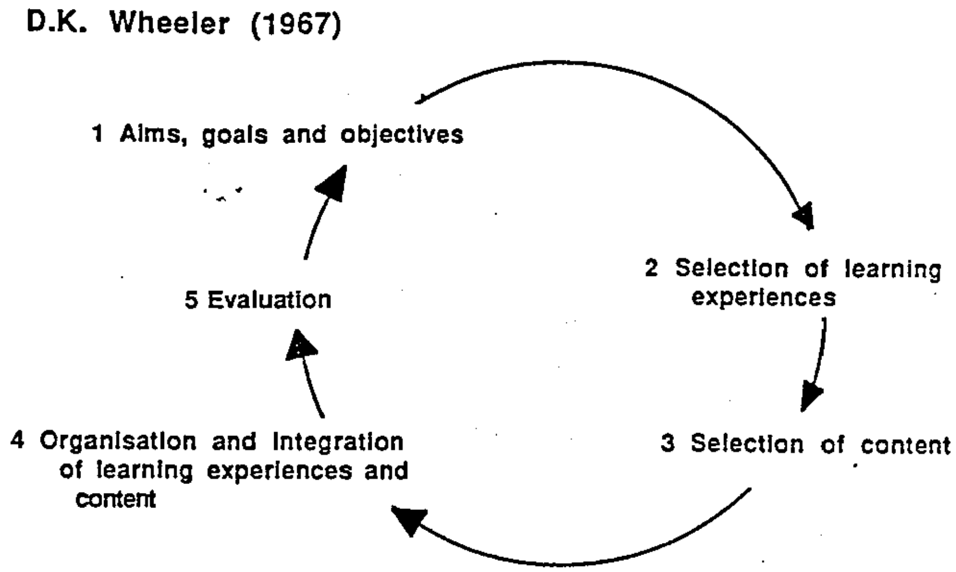


FIGURE 2.3 - WHEELER's OBJECTIVE MODEL

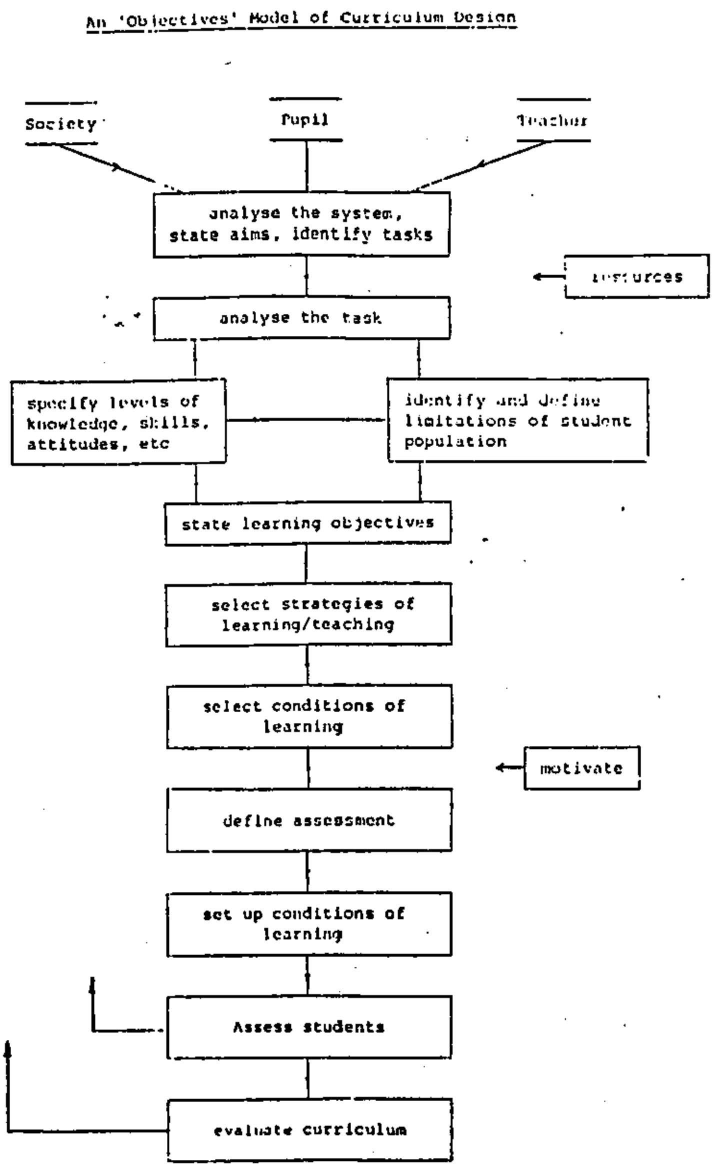


FIGURE 2.4 - ALTERNATIVE TYPE OBJECTIVE MODEL

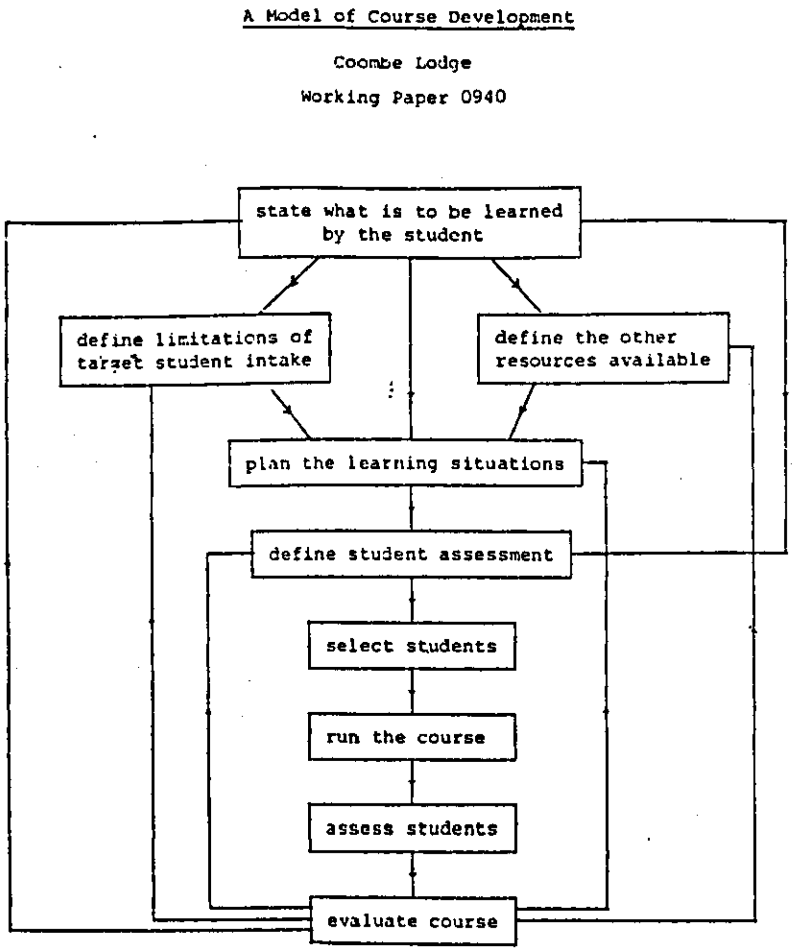
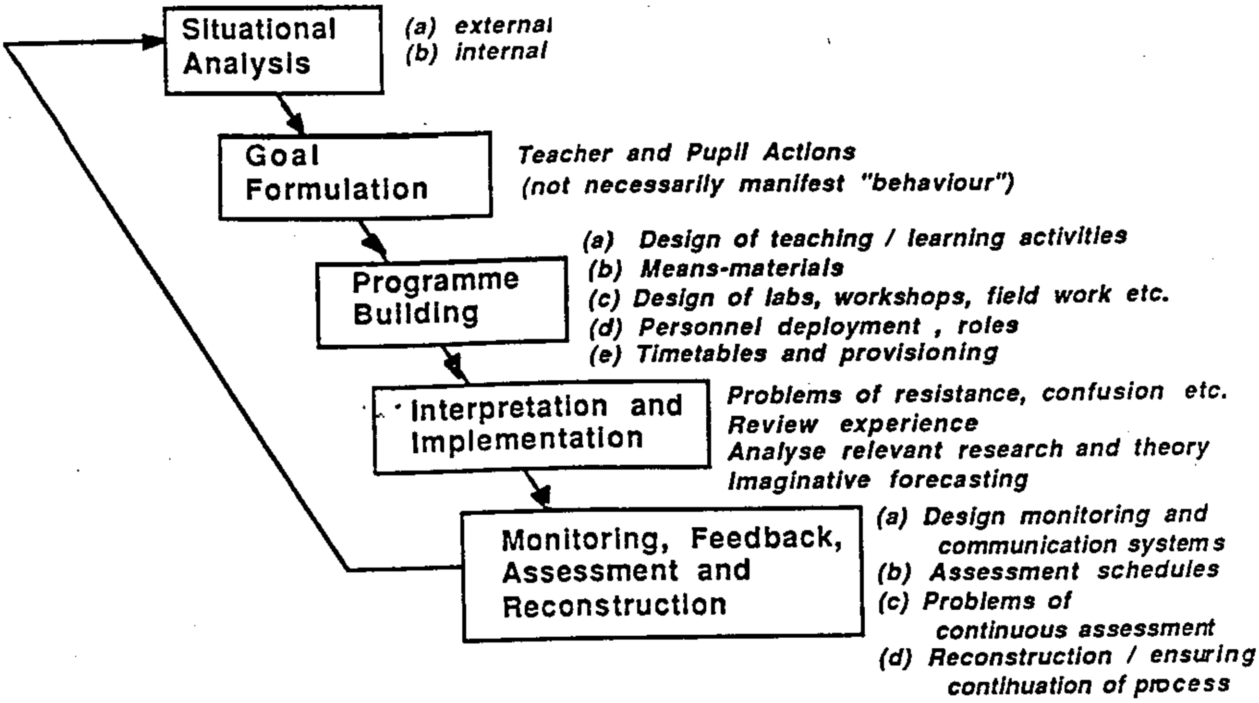


FIGURE 2.5 - COOMBE LODGE MODEL FOR CURRICULUM DESIGN



Situational Analysis

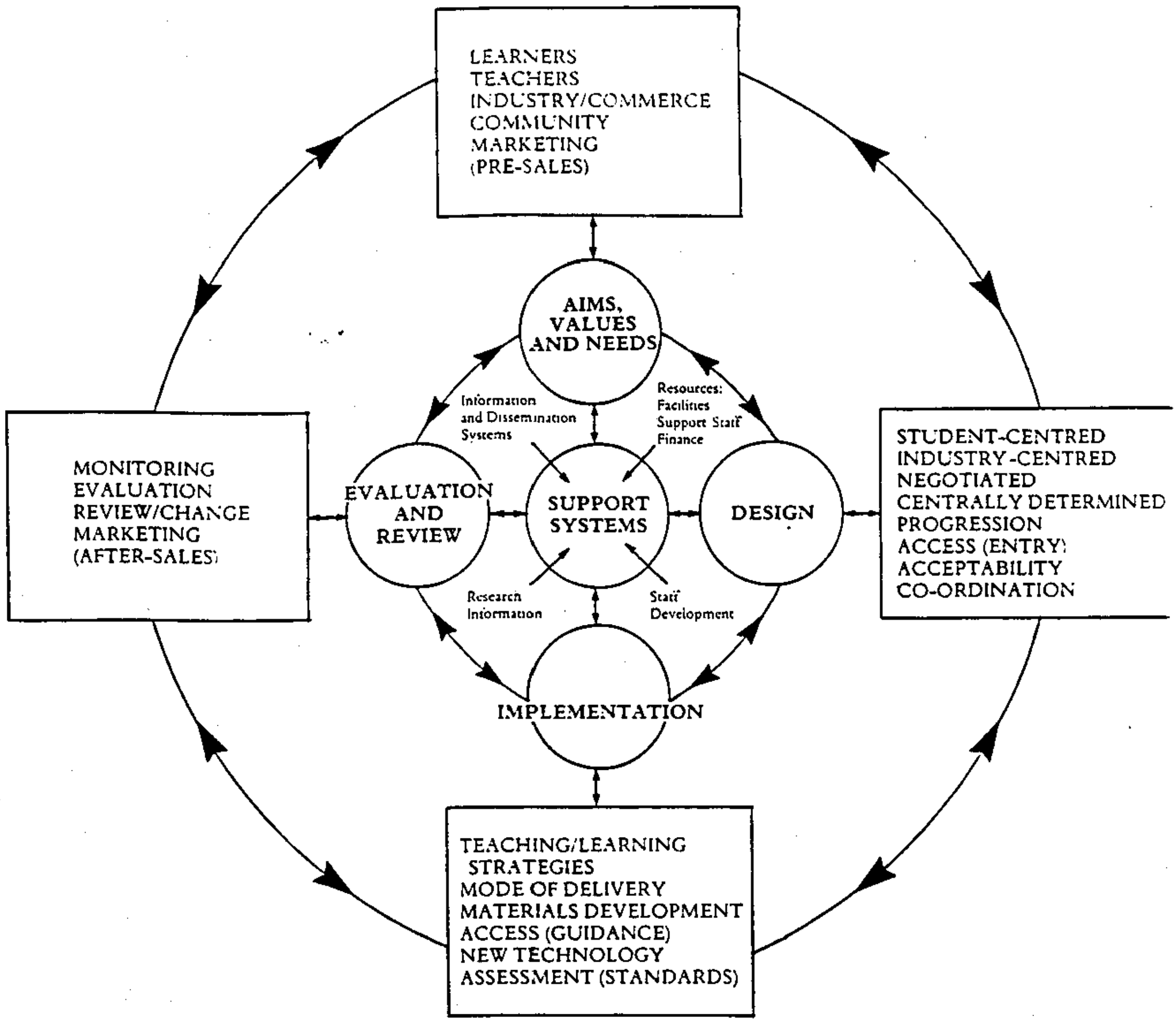
External

(i) Culture, Society, Ideologies, Parents, Employers
(ii) Education System, Government, LEA, Exams, Projects, Research
(iii) Nature of Subject Matter
(iv) Teacher Support Systems
(v) Resource Input

Internal

(i) Pupils
(ii) Teachers
(iii) School
(iv) Material Resources
(v) Existing Curriculum

FIGURE 2.6 - SITUATIONAL CURRICULUM MODEL



INNER CIRCLE AND HUB-
The curriculum development cycle

OUTER CIRCLE-
Features of each stage in the cycle

FIGURE 2.7 - FURTHER EDUCATION UNIT CURRICULUM DEVELOPMENT MODEL

Table 1 shows, the pass rate in ONC in 1969 was 62 per cent as compared to 68 in OND, and 73 per cent in HNC as compared to 77 in HND.

TABLE 1

Further education examinations: entrants and passes

Part-time courses	*1961*	*1966*	*1969*
1. *CGLI* (all subjects)			
Entries	133,068	241,806	356,780
Passes	82,929	165,385	258,756
Percentage passes	62	68	73
2. *ONC* (all subjects)			
Entries	38,138	29,154	23,627
Passes	19,453	17,802	14,625
Percentage passes	51	61	62
3. *HNC* (all subjects)			
Entries	17,422	21,673	18,189
Passes	11,719	14,293	13,291
Percentage passes	67	66	73
Full-time courses			
1. *OND* (all subjects)			
Entries	921	3,817	5,032
Passes	561	2,568	3,504
Percentage passes	61	67	70
2. *HND* (all subjects)			
Entries	1,260	3,257	5,658
Passes	1,054	2,703	4,386
Percentage passes	83	83	77
3. *NDD/Dip.AD*			
Entries	1,574*	1,755†	1,950‡
Passes	1,286	1,526	1,835
Percentage passes	82	89	94

* NDD only. † NDD and Dip.AD. ‡ Dip.AD only.

TABLE 2.1 - ILLUSTRATES REDUCTION IN WASTAGE ON NATIONAL AND HIGHER NATIONAL CERTIFICATE/DIPLOMA COURSES

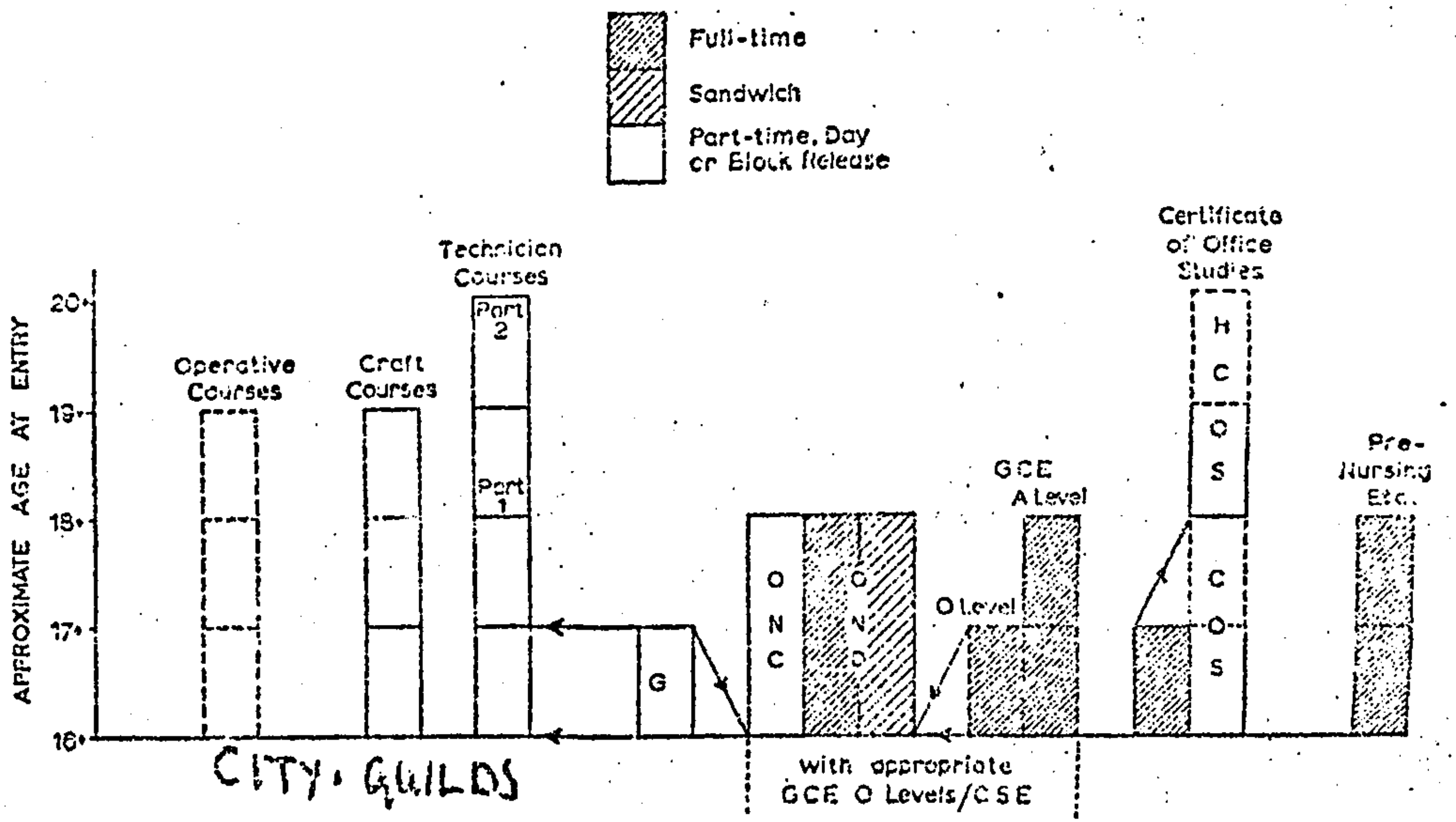
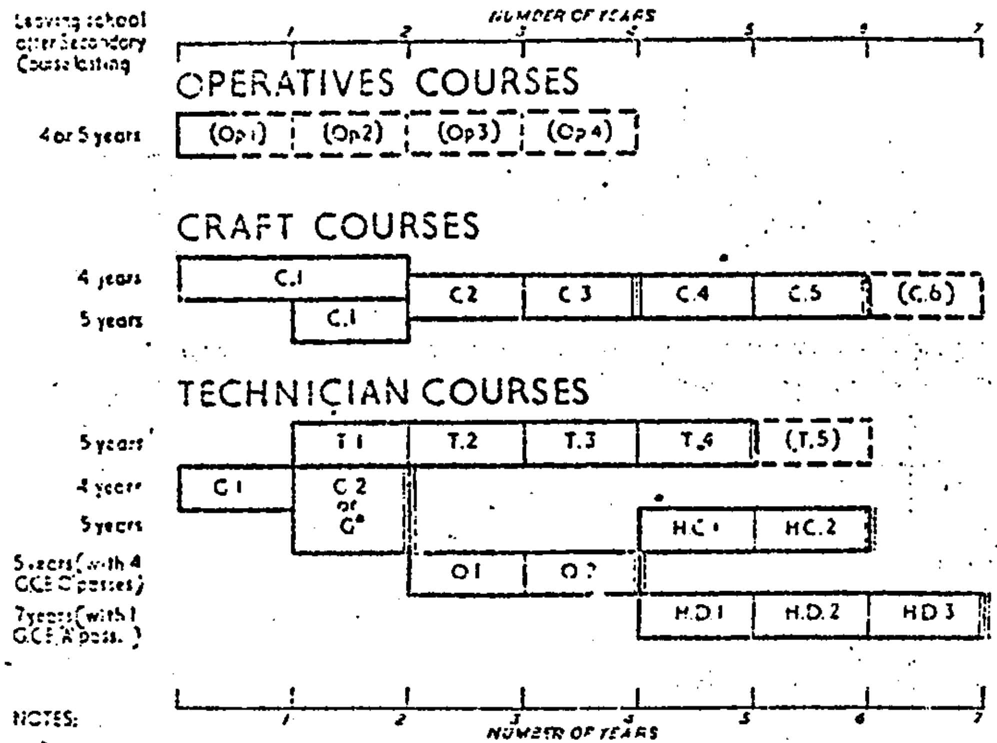


FIGURE 2.8 - NON ADVANCED COURSES: BASIC PATTERN

FIGURE 2.9 - BETTER OPPORTUNITIES IN TECHNICAL EDUCATION 1961 - OUTLINE OF NEW PATTERN OF COURSES

OUTLINE OF THE NEW PATTERN OF COURSES



Op Operatives Course (These courses vary greatly in length)

C Craft Course.

T Technician Course

G General Course.

O Ordinary National Certificate or Diploma Course (The Certificate Courses are part-time; the Diploma Courses full-time or sandwich).

HC. Higher National Certificate Course (part-time).

HD. Higher National Diploma (fulltime or sandwich).

Denotes an intermediate or final stage associated with an examination.

* Students leaving secondary school after a 5 year course will normally take a one-year General Course.

NOTES:

(i) Courses for Degrees, Diplomas in Technology or other qualifications leading direct to technologist status are not shown. Students gaining Higher National Diplomas or Certificates may also reach technologist status by further study; such further courses are not shown.

(2) This outline does not show all the possible routes open to the individual. For example, there will be opportunities for some students to transfer from a course of one level to an appropriate point in a higher course.

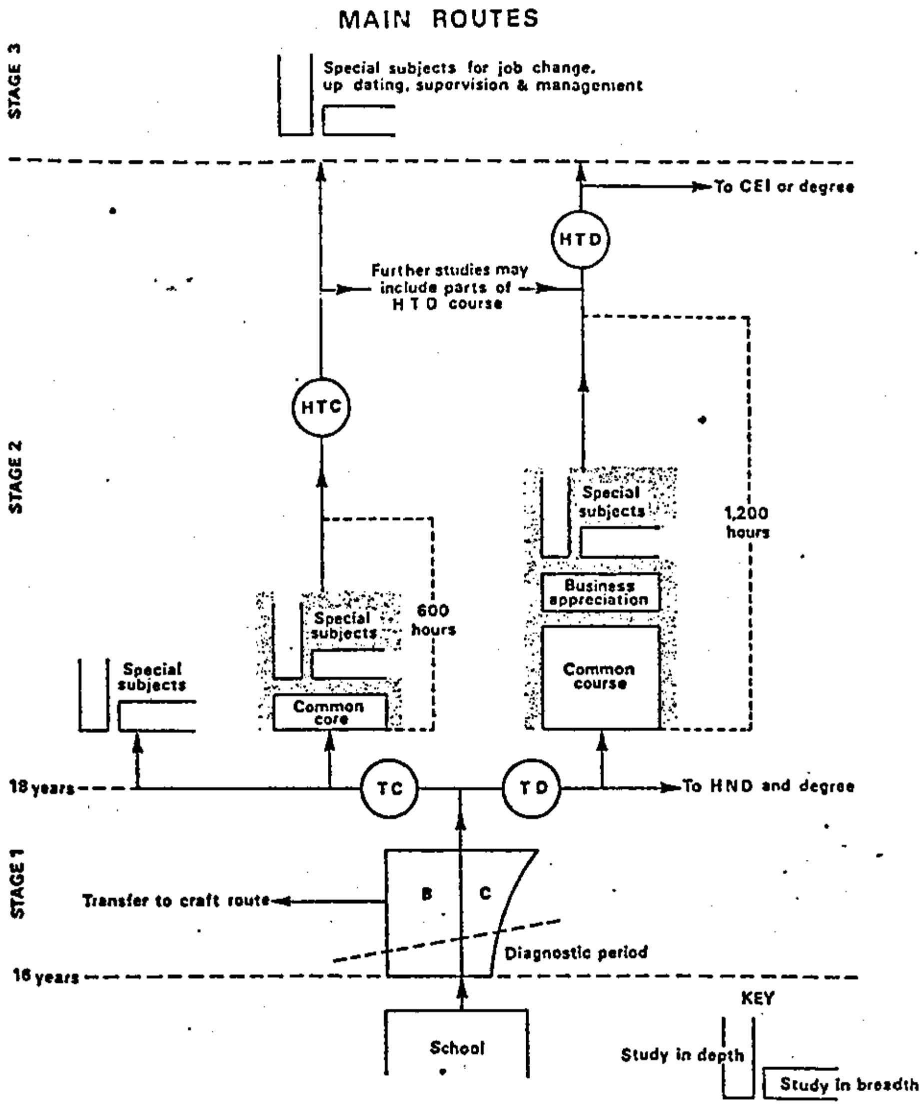


FIGURE 2.10 - UNIFIED PATTERN OF COURSES FOR THE TEC CERTIFICATE AND HIGHER TECHNICIAN CERTIFICATE COURSES

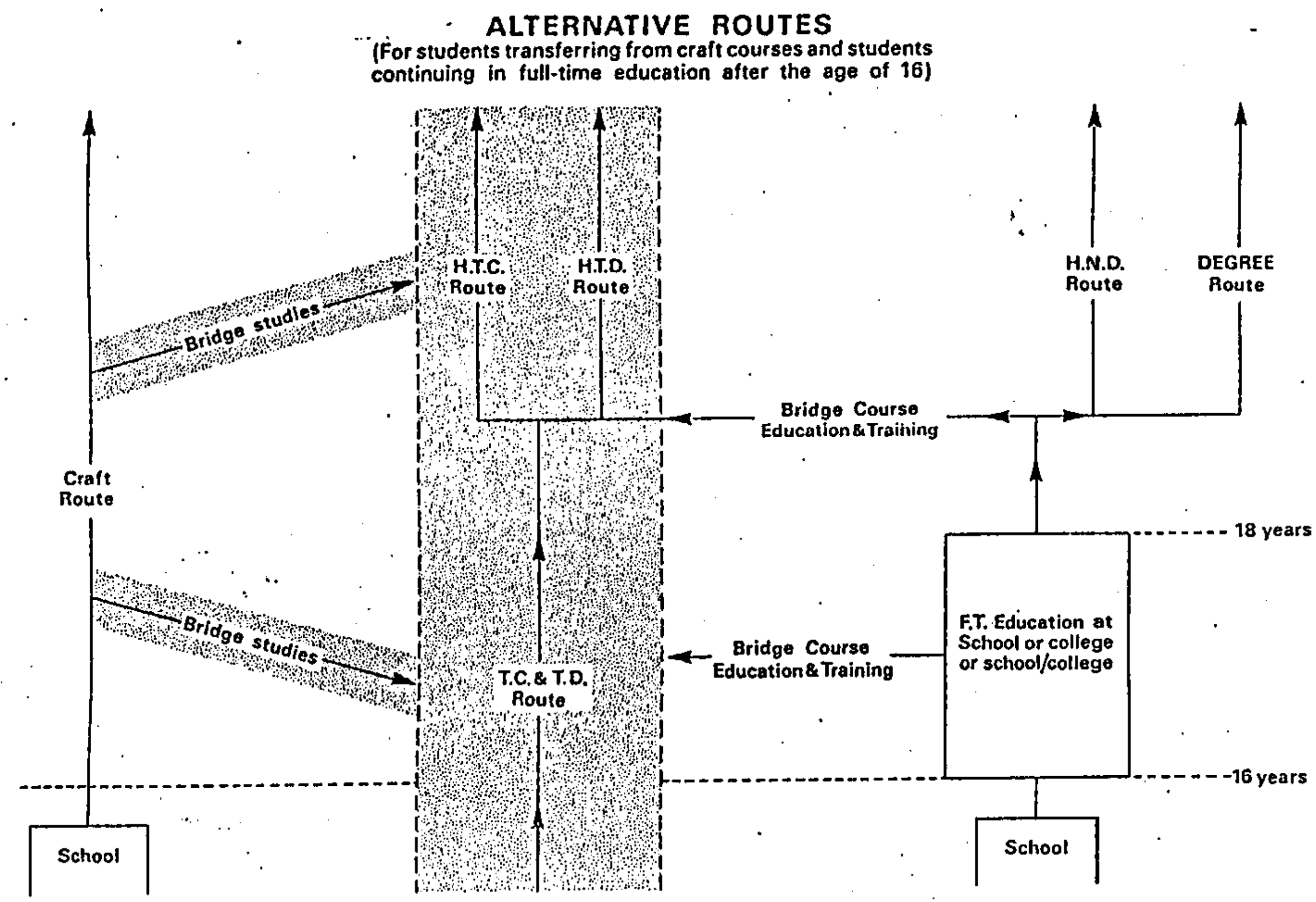


FIGURE 2.11 - ALTERNATIVE ROUTES FOR TRANSFER FROM CRAFT COURSES OR FULL TIME EDUCATION

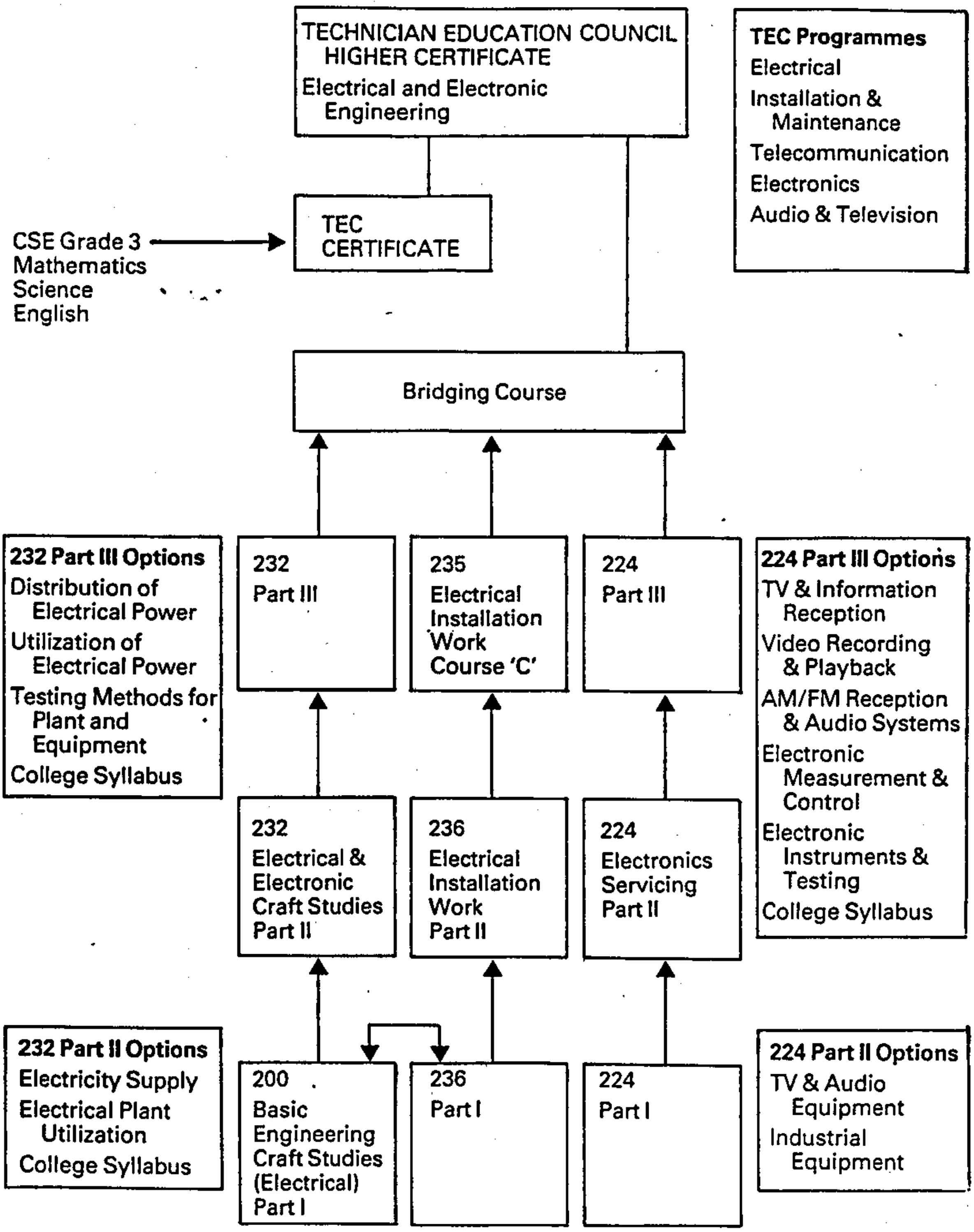


FIGURE 2.12 - SCHEMES OF FURTHER EDUCATION IN ELECTRICAL AND ELECTRONIC ENGINEERING

WALSALL COLLEGE OF TECHNOLOGY

ELECTRICAL AND ELECTRONIC INDUSTRY

T.E.C. CERTIFICATE PROGRAMMES

LEVEL

TECHNICIAN CATEGORY \ UNIT TITLE	MATHEMATICS 75/005	PHYSICAL SCIENCE 75/004	MATLS & W.S.PRACT. 76/002	ELECT. D W G 75/011 A	E'CAL & E'NIC SYSTEMS C.D.	TELECOMM. SYSTEMS 76/007	MICRO ELECTRONIC SYSTEMS 79/602
UNIT VALUE	1	1	1	1	1	1	½
✱GENERAL ELECTRICAL ...	E	E	E	E	E		
ELECTRICITY SUPPLY ...	E	E	E	E	E		
✱ INSTALL. & MAINT. ...	E	E	E	E	E		
✱ TELECOMMUNICATIONS ...	E	E	E	E		E	
COMMUNICATIONS	E	E	E	E		E	
✱ ELECTRONICS	E	E	E	E	E		
AUDIO & TELEVISION ...	E	E	E	E	E		
✱ MICRO ELECTRONICS ...	E	E	E	E			E

LEVEL II

TECHNICIAN CATEGORY \ UNIT TITLE	MATHEMATICS 76/033 A	ELECTRICAL PRINC. 75/019	E'CAL APP. C.D.	E'NIC APP. C.D.	E'CAL INSTALL. C.D.	ENG. SCIENCE C.D.	ELECTRONICS 76/010	RADIO & T.V. EQUIP. C.D.	TRANS. SYST. 76/006	RADIO SYST. 76/013	TELE. SW. SYST. 76/005	MICRO ELECTRONIC SYSTEMS 79/603
UNIT VALUE	1	1	1	1	1	1	1	1	½	½	½	1
✱GENERAL ELECTRICAL	E	E	E	E			E					
ELECTRICITY SUPPLY	E	E	E		E	E						
✱ INSTALL. & MAINT.	E	E	E		E							
✱ TELECOMMUNICATIONS	E	E					E		E		E	
COMMUNICATIONS	E	E					E			E	E	
✱ ELECTRONICS	E	E		E			E					
AUDIO & TELEVISION	E	E					E	E				
✱ MICRO ELECTRONICS	E	E					E					E

LEVEL III

TECHNICIAN CATEGORY \ UNIT TITLE	E'CAL PRINC. 75/010	E'CAL INSTALL. C.D.	E'CAL APP. C.D.	E'NIC APP. C.D.	ELECTRONICS 76/009	ENG. SCIENCE C.D.	T.V. EQUIP. C.D.	INSTALL. & TEST C.D.	" (E'NIC) C.D.	" (T.V.) C.D.	DIGITAL TECH. 76/011	RADIO SYSTEMS 76/014	TELE SW SYST. 76/004	TRANS. SYST. 76/012	PROJECT C.D.	COMMISSIONING & MAINT. C.D.	MICRO ELECTRONIC SYSTEMS
UNIT VALUE	1	1	1	1	1	1	1	½	1	1	½	1	1	½	½	½	1½
✱GENERAL ELECTRICAL	E		E	E													
ELECTRICITY SUPPLY	E		E			E											
✱ INSTALL. & MAINT.	E	E	E					P							P	P	
✱ TELECOMMUNICATIONS	E				E						E		E	O	O		
COMMUNICATIONS	E				E						E	E		O	O		
✱ ELECTRONICS	E			E	E				E								
AUDIO & TELEVISION	E				E		E			E							
✱ MICRO ELECTRONICS	E				E				E								E

E — ESSENTIAL UNIT

S — SUPPLEMENTARY UNIT

O — CHOICE OF ONE OPTIONAL UNIT

P — CHOICE OF TWO OPTIONAL UNITS

ALL PROGRAMMES INCLUDE TWO UNITS (120 HOURS) OF COMMUNICATION — GENERAL STUDIES

✱ ACTUAL COURSES FOLLOWED IN THE DEPARTMENT

FIGURE 2.13 - INITIAL BTEC NATIONAL CERTIFICATE PROGRAMME STRUCTURES

Each programme will have the following common core units.

CORE UNITS	UNIT VALUE
MATHEMATICS I	1.0
PHYSICAL SCIENCE I	1.0
INDUSTRIAL SKILLS AND PRACTICE	1.0
ELECTRICAL AND ELECTRONIC SYSTEMS	1.0
MATHEMATICS II	1.0
ELECTRICAL AND ELECTRONIC PRINCIPLES II	1.5
DIGITAL TECHNIQUES II	0.5
ELECTRONIC APPLICATIONS II	0.5
ELECTRICAL AND ELECTRONIC PRINCIPLES III	1.0
GENERAL AND COMMUNICATION STUDIES A	1.0
GENERAL AND COMMUNICATION STUDIES B	1.0

The specified programmes will be completed by addition to the following units.

ELECTRONICS

UNIT	UNIT VALUE
MICROELECTRONIC SYSTEMS I	0.5
MICROELECTRONIC SYSTEMS II	1.0
ELECTRONICS III	1.0
DIGITAL TECHNIQUES III	1.0
ELECTRONIC APPLICATIONS III	1.0

ELECTRICAL ENGINEERING

UNIT	UNIT VALUE
ENGINEERING DRAWING APPRECIATION	0.5
ELECTRICAL APPLICATIONS II	0.5
INSTALLATION TECHNOLOGY II	1.0
INSTALLATION TECHNOLOGY III	1.0
ALARM & CONTROL SYSTEMS III	0.5
ELECTRICAL APPLICATIONS III	1.0

ELECTRICAL AND ELECTRONIC ENGINEERING

UNIT	UNIT VALUE
ENGINEERING DRAWING APPRECIATION	0.5
MICROELECTRONIC SYSTEMS I	0.5
ELECTRICAL APPLICATIONS II	0.5
ELECTRONICS III	1.0
ELECTRONIC APPLICATIONS III	1.0
ELECTRICAL APPLICATIONS III	1.0

FIGURE 2.14 - BTEC NATIONAL CERTIFICATE REVISED PROGRAMME STRUCTURES.

WALSALL COLLEGE OF TECHNOLOGY

ELECTRICAL AND ELECTRONIC ENGINEERING

T.E.C. HIGHER CERTIFICATE PROGRAMMES

Level	Unit Title	Unit Value	Installation & Maintenance	Electronics	Audio & Television	Telecommunication	General Electrical	Micro-Electronics
LEVEL III	01 MATHEMATICS	1	E	E	E	E	E	E
	02 ELECTRONICS	1					E	
	03 DIGITAL TECHNIQUES	½			E			
	04 ELEMENTS OF CONTROL	1	E	E				E
	05 MICROPROCESSOR APPRECIATION	½	E	E			E	
LEVEL IV	06 ELECTRICAL PRINCIPLES	1	E	E	E	E	E	E
	07 DIGITAL TECHNIQUES	1		E	E	E		E
	08 UTILISATION OF ELECTRICAL ENERGY	1	E				E	
	09 ELECTRICAL ENGINEERING SERVICES	1	E					
	10 ELECTRONICS	1		E	E	E	E	E
	11 TELEPHONY & TRANSMISSION	1½				E		
	12 COLOUR TV PRINCIPLES	1			E			
	13 AUDIO & VIDEO TAPE SYSTEMS	1			E			
	14 ELECTRICAL ENGINEERING MANAGEMENT	1	E					
	15 MICROCOMPUTER PRINCIPLES	1		P			E	
	16 INDUSTRIAL CONTROL & APPLICATIONS	1		P				
	17 TEROTECHNOLOGY	1	E	E	E	E	E	E
	18 MANAGEMENT & COMMUNICATION STUDIES	1	E	E	E	E	E	E
	19 MICROPROCESSOR BASED SYSTEMS	1						E
LEVEL V	20 TELEPHONY & TRANSMISSION	1				E		
	21 COLOUR TELEVISION	1			E			
	22 PROJECT	½	E	E	E	E	E	
	23 ELECTRONIC APPLICATIONS	1		E			P	E
	24 UTILISATION OF ELECTRICAL ENERGY	1	E				P	
	25 ELECTRICAL PRINCIPLES	1				E		
	26 MICROPROCESSOR BASED SYSTEMS	1						E

E – ESSENTIAL UNIT P – OPTIONAL UNIT

FIGURE 2.15 - INITIAL BTEC HIGHER NATIONAL CERTIFICATE PROGRAMMES.

BTEC HNC IN ELECTRONICS

For the technician with a need to understand the hardware aspects of microprocessor based systems. It is envisaged that the technician will require a substantial understanding of the problems of interfacing between the microprocessor and the "outside world" as well as an appreciation of the programming aspects of microprocessor operation.

CORE UNITS

UNIT TITLE	UNIT VALUE
MATHEMATICS III	1.0
MEASUREMENTS AND CONTROL III	1.0
MICROELECTRONIC SYSTEMS III	1.5
ELECTRICAL AND ELECTRONIC PRINCIPLES IV	1.0
ELECTRONICS IV	1.0
DIGITAL TECHNIQUES IV	1.0
MANAGEMENT AND COMMUNICATION STUDIES IV	1.0
ELECTRONIC INSTRUMENTATION IV	0.5

The core units provide a total of 8 units towards the higher certificate, the remaining two units may be chosen from the following list of optional units. Additional units from this list may be added to the HNC as supplementary units.

UNIT TITLE	UNIT VALUE
MICROPROCESSOR BASED SYSTEMS IV	1.0
CONTROL APPLICATIONS IV	1.0
MATHEMATICS IV	1.0
INDUSTRIAL ELECTRONICS V	1.0
INDUSTRIAL MEASUREMENTS AND PROCESSES V	1.0
MICROPROCESSOR BASED SYSTEMS V	1.0

FIGURE 2.16 - BTEC HIGHER NATIONAL CERTIFICATE REVISED PROGRAMME STRUCTURES.

<u>APPENDICES 1</u>

<u>EXAMPLE OF TYPICAL NATIONAL CERTIFICATE</u>

<u>STANDARD UNIT</u>

TEC U79/603
Microelectronic Systems II

TECHNICIAN EDUCATION COUNCIL

Standard Unit

1. UNIT TITLE: Microelectronic Systems

2. UNIT LEVEL: II

3. UNIT VALUE: One Design Length 60 hours

4. PROGRAMMES:

The guidelines produced by Programme Committees indicate the standard units that they see for possible incorporation in their programmes.

5. PRE-REQUISITE UNITS:

Microelectronic Systems I
Mathematics I

6. CREDITS FOR UNITS:

7. AIMS OF THE UNIT:

1. To introduce the binary system of addition and subtraction.
2. To explain the fetch/execute cycle.
3. To extend machine level programming to allow a program using a loop to be written and executed.
4. To develop the principles of storage and bus mechanisms.

8. SPECIAL NOTES:

9. ASSESSMENT ANALYSIS

This gives a very approximate analysis, by topic and type of learning, as a key to the production by a college of its assessment specification for this unit.

Unit topic area(s)	Topic area(s) as % of assessment	% of total assessment				
		Motor skills	Intellectual skills			
			Information	Comprehension	Application	Invention
A	7		2	2	3	
B	20		8	8	4	
C	28		5	13	10	
D	5		5			
E	25		5	10	10	
F	5		3	2		
G	10		2	2	6	
Percentage of assessment for entire unit	→		30	37	33	

10. UNIT CONTENT

The unit topic areas and the general and specific objectives are set out below, the unit topic areas being prefixed by a capital letter, the general objectives by a non-decimal number, the specific objectives by a decimal number. THE GENERAL OBJECTIVES GIVE THE TEACHING GOALS AND THE SPECIFIC OBJECTIVES THE MEANS BY WHICH THE STUDENT DEMONSTRATES HIS ATTAINMENT OF THEM. Teaching staff should design the learning process to meet the general objectives. The objectives are not intended to be in a particular teaching sequence and do not specify teaching method but, for example, practical work could be the most appropriate teaching method for the achievement of the objectives.

ALL THE OBJECTIVES SHOULD BE UNDERSTOOD TO BE PREFIXED BY THE WORDS: THE EXPECTED LEARNING OUTCOME IS THAT THE STUDENT:

A. BINARY AND LOGIC

1. Understands the principles of binary addition and subtraction.

1.1 States that computers hold and manipulate data as patterns of binary states.
1.2 Explains that the binary number system is a convenient, but not the only way, of manipulating the patterns in 1.1.
1.3 Defines the binary system of numbers and derives the equivalent of binary numbers.
1.4 Defines the octal and hexadecimal system of numbers and derives the octal and hexadecimal equivalent of binary numbers.
1.5 Extends 1.3 and 1.4 to reverse the derivation.
1.6 Explains the main application and advantages of the octal and hexadecimal systems.
1.7 States the rules of binary addition including the carry function.
1.8 Applies the rules of binary addition.
1.9 States that negative numbers are normally represented in twos complement form.
1.10 Explains the rules of twos complement notation.
1.11 Uses 1.9 and 1.10 to perform binary subtraction.

B. THE FETCH/EXECUTE CYCLE

2. Understands the function of the main components of the CPU.

2.1 Defines the term register.
2.2 Explains typical properties and uses of a register.

2.3 Explains that an instruction comprises two parts:

a) the operator - the part defining which operation is to be performed.
b) the operand - the part defining the data or location of data which is to be used by the operation.

2.4 Draws a CPU containing:

a) Instruction Register (R)
b) Program Counter (PC)
c) Store Address Register
d) Accumulator
e) Arithmetic and Logic Unit (ALU)
f) Status register
g) Control and Timing Devices

2.5 Explains the basic purpose of each unit in 2.4
2.6 States that carrying out an instruction involves the Fetch/Execute Cycle.
2.7 Defines the term Fetch.
2.8 Defines the term Execute.
2.9 Explains the basic operation as being fetching the instruction to the CPU, decoding the instruction within the CPU, fetching more data if required and executing the instruction.
2.10 Demonstrates the mechnism in 2.9 by using; for example, an add from memory into the accumulator.

C. <u>PROGRAM CREATION AT MACHINE CODE LEVEL</u>

3. Draws a flow chart to solve a problem.

3.1 Explains for any given problem a set of steps called an algorithm must be created which will solve the problem or will indicate that a solution can not be found.
3.2 States that the next step in program creation is the generation of a flow chart from the algorithm.
3.3 States that until the flow chart has been drawn it is normally impossible to write a satisfactory program.
3.4 Defines the algorithm, draws the flow chart and writes the program to solve a given sample problem, such as the addition of two words from store putting the results back into store.
3.5 Writes the contents of each register (in 2.4) and relevant store locations before and after the execution of each instruction ie a trace table.
3.6 States that in order to load and execute a simple program some software must already exist within the machine.

3.7. Verifies the trace table by loading and single stepping the program.

D. INSTRUCTION SETS

4. Understands the main types of instructions.

4.1 States that the main types of instructions may be grouped into the following:

a) Data Transfer Group
b) Arithmetic and Logic Group
c) Test and Branch Group

4.2 Gives examples of the instructions in each group in 4.1.
4.3 Defines the type of addressing in 3.4.
4.4 States that the program in 3.4 only required the use of one type of addressing and that more complicated programs make use of other forms of addressing.

E. PROGRAMS WITH LOOPS

5. Writes a program containing a loop.

5.1 Defines a loop as a body of program which is repeated a number of times.
5.2 Explains that the number of passes around the loop is controlled by a parameter which is changed on each pass of the loop.
5.3 Explains that the parameter in 5.2 is tested on each pass of the loop.
5.4 States that a loop may contain an instruction whose operand can be changed at each pass of the loop.
5.5 States that the operand of the jump instruction in 5.3 must enable the program counter to locate the next instruction.
5.6 Employs an algorithm, draws a flow chart, writes and executes a program, using a loop control counter to add five numbers together stored in separate memory locations and storing the result in a sixth location.
5.7 Selects from a given list the appropriate instructions to the program in 5.6.

F. STORE

6. Understands the relationship between CPU and store.

6.1 States that a store contains a number of locations.
6.2 States that each store location has a unique address.
6.3 States that each location within a store contains a predetermined number of bits.

6.4 States that only one storage location should be connected to the data bus at any one time.

6.5 Explains that with n address lines there are 2^n available stores.

6.6 Explains why most proprietary store chips include some address decoding circuitry in addition to the storage elements.

6.7 States that any location in store can contain data or instructions or garbage.

6.8 Explains the terms:

a) Chip Select/Enable
b) Read/Write Control
c) Data and Address Lines.

7. Understands Bus Mechanisms.

7.1 Explains the purpose of the data, address and control bus.

7.2 States that the data bus allows information to flow in either direction ie Bidirectional.

7.3 States that, in general, only one input and output are 'actively' connected at any one time.

7.4 Explains that the normal way of acheiving the connection in 7.3 is the use of a tri-state device.

7.5 Uses a truth table to explain the function of a tri-state device.

7.6 States that the control device can provide a signal to activate the store for either reading or writing.

7.7 States that the control device can provide a signal to achieve either store or input/output routes.

G. INTERFACING

8. Understands the principles of interfacing.

8.1 States that the connection of a peripheral device to the microcomputer data bus may require:

a) Electrical buffering
b) Code conversion
c) Change in number of lines
d) Timing control.

8.2 Explains the term buffer.

8.3 Relates the purpose of the buffer to 8.1 a) and d).

8.4 Draws a block diagram of a microprocessor system which has input and output ports connected to (for example) keys and an LED output device via buffers.

8.5 Modifies the program in 5.6 to input five numbers from keys, to add them together and to output the results to an LED display.

8.6 Implements the program.

APPENDICES 2

EXAMPLE OF TYPICAL HIGHER NATIONAL

CERTIFICATE STANDARD UNIT

TECHNICIAN EDUCATION COUNCIL

Standard Unit

1. UNIT TITLE: MICROPROCESSOR BASED SYSTEMS

2. UNIT LEVEL: IV

3. UNIT VALUE: One DESIGN LENGTH: 60 Hours

4. PROGRAMMES:

The guidelines produced by Programme Committees indicate the standard units that they see for possible incorporation in their programmes.

5. PRE-REQUISITE UNITS:

Microelectronic Systems III U79/604

6. CREDITS FOR UNIT:

7. AIMS OF THE UNIT:

(1) To develop a procedure to compare microprocessor based systems.

(2) To introduce the principles of fault location in microprocessor based systems.

(3) To detail the procedure for system development.

(4) To program memories.

8. SPECIAL NOTE

The devices in unit topic area D should all be non volatile devices.

9. ASSESSMENT ANALYSIS

The following gives the unit breakdown, by topic and types of learning, as a key to the production by a college of its assessment specifications for this unit.

Unit/Subject topic area(s)	Topic area(s) as % of assessment	% of total assessment				
		Motor skills	Intellectual skills			
			Information	Comprehension	Application	Invention
A	12				2	10
B	10		1	6	3	
C	70		5	10	40	15
D	8		1		7	
Percentage of assessment for entire unit/subject →			7	16	52	25

10. UNIT CONTENT

The unit topic areas and the general and specific objectives are set out below, the unit topic areas being prefixed by a capital letter, the general objectives by a non-decimal number, the specific objectives by a decimal number. THE GENERAL OBJECTIVES GIVE THE TEACHING GOALS AND THE SPECIFIC OBJECTIVES THE MEANS BY WHICH THE STUDENT DEMONSTRATES HIS ATTAINMENT OF THEM. Teaching staff should design the learning process to meet the general objectives. The objectives are not intended to be in a particular teaching sequence and do not specify teaching method but, for example, practical work could be the most appropriate teaching method for the achievement of the objectives.

ALL THE OBJECTIVES SHOULD BE UNDERSTOOD TO BE PREFIXED BY THE WORDS: THE EXPECTED LEARNING OUTCOME IS THAT THE STUDENT:

A. MICROPROCESSOR SYSTEMS

1. Evaluates the characteristics of current microprocessor systems using manufacturers' data.

1.1 Analyses some of the important physical features of a microprocessor as being:

(i) word length/data bus length
(ii) speed of operation of a typical instruction
(iii) size and facilities of instruction set (including available addressing modes).
(iv) size of address bus
(v) power requirements
(vi) I/O facilities.

1.2 Identifies system devices, such as:

(i) CPU
(ii) Memory
(iii) I/O devices
(iv) clock
(v) bus buffer
(vi) bus demultiplexers
(vii) decoders

1.3 Analyses differing microprocessor systems in typical applications, i.e.

(i) small dedicated e.g. washing machine controller
(ii) semi dedicated e.g. word processor or PLC - (Programmable Logic Control).
(iii) general purpose e.g. microcomputer development system

with reference to:

a) appropriate device technology
b) average chip count
c) total cost
d) predicted production volume.

1.4 Explains the use of bench marks for purposes of comparing different systems.

B. FAULT LOCATION

Introduces the principles of fault location in microprocessor based systems.

2.1 Lists typical faults that can occur in microprocessor systems as:

(i) chip failure
(ii) open circuit interconnection
(iii) bridging or short circuit interconnection
(iv) externally induced interference
(v) original software bugs

2.2 Explains the use of conventional techniques for fault finding as:

(i) DC test
(ii) use of logic probe
(iii) use of CRO
(iv) visual inspection

2.3 Explains the use of:

(i) logic analyser
(ii) signature analyser
(iii) use of software diagnostics both resident and non-resident in detection of faults listed in 2.1. (above).

2.4 Compares traditional methods and specialist techniques for diagnosing faults, with reference to 2.3.

C. SYSTEM DEVELOPMENT

3. Recognises the steps in the development of a microprocessor system.

3.1 Analyses the typical stages used in developing systems as:

(i) initial specification of complete system ;
(ii) formulation of measures of cost effectiveness ;
(iii) derivation of a system flow chart ;
(iv) definition of hardware/software implementation;
(v) selection of necessary electronic devices, controller, etc. and the necessary interfacing devices;
(vi) definition of boundary constraints for the microcomputer program, e.g. timing, address space;
(vii) development of program flow chart;
(viii) writing of program;
(ix) testing of program;
(x) modification where necessary;
(xi) simulation/emulation of system;
(xii) further modification where necessary

(xiii) running of hardware and firmware protype
(xiv) iteration as necessary

3.2 Recognises that the ratio of testing and debugging period to initial development time rises significantly with complexity of the task.

4. Understands the uses of devlopment systems.

4.1 States that the development system is used to expedite 3.1 (vii),(viii), (ix), (x) and (xi).

4.2 States that typical facilities within a development system can be:

(i) operating program consisting of:

(a) operating system and monitor
(b) editor
(c) assembler
(d) debugger
(e) PROM programmer
(f) loader
(g) linker
(h) locater
(j) software trace

(ii) Memory - for applications program development
- for operating system
- for non volatile bulk storage

(iii) keyboard and VDU/printer

(iv) PROM programmer

(v) I/O facilities

(vi) in circuit emulator

4.3 Uses a system to enter, edit, assemble and debug a program.

4.4 Relates 4.3 to (viii), (ix) and (x) in 3.1

4.5 Tests the software with appropriate hardware peripherals

4.6 Given a flow chart, instruction set and peripheral hardware, uses a system to demonstrate that a program will perform a specified task.

D. <u>PRACTICAL ASPECTS OF PROGRAMMABLE MEMORY</u>

5. Demonstrates the correct chip programming procedure

5.1 Uses manufacturers' data to select programmable memory devices.
5.2 Uses manufacturers' data to define operating conditions for programmable memory devices.
5.3 Uses EPROM to store developed program
5.4 Uses development system to program programmable memory devices.
5.5 States the procedure for erasing EPROM

APPENDICES 3

NEW PATTERN OF BTEC NATIONAL

CERTIFICATE COURSES

Principal: J. Hicks MA
Director of Education: R. D. Nixon MA

Walsall College of Technology St. Paul's Street, Walsall WS1 1XN Telephone: 25124 (3 lines).

EPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ead of Department:
D. HOMER, B.Sc.

BTEC FIRST DIPLOMA IN ENGINEERING

he course consists of a coherent scheme of unitised study in which the student ttempts 8 Essential values, normally completed over one year full time.

EF.	UNIT TITLE	CONTENTS SUMMARY	% OF UNIT
F01	Engineering Fundamentals F (2.0)	Safety at Work	5
		Hand and Machine Processes)	
		Fastening and Joining materials)	20
		Working in Plastics)	
		Materials	10
		Engineering Drawing	20
		Electrical Measuring Instruments)	
		Electrical Connection and Termination)	
		Lighting and Power Circuits)	20
		Electrical Protection)	
		Electronic Systems)	
		Integrative assignments	25
F02	Mathematics F (1.0)	Arithmetic	30
		Algebra	35
		Geometry and Trigonometry	25
		Statistics	10
F03	Science F (1.0)	Oxidation	10
		Statics	25
		Motion and Energy	35
		Electricity	30
F04	Information Technology Studies F. (1.0)	Introduction to information Technology	10
		Computing	45
		Information Technology Applications	20
		Integrative assignments	25
F05	Vocational Assignments F. (1.0)	Planning	15
		Implementation	50
		Presentation	15
		Evaluation	20
F09	Instrumentation and Process Measurements F (1.0)	Basic Instrument Systems	30
		Basic Fluid Measurement)	
		Basic Pressure Measurement)	
		Basic Level Measurement)	45
		Basic Flow Measurement)	
		Basic Temperature Measurement)	
		Maintenance and Installation	25

/Continued

Principal: J. Hicks MA
Director of Education: R. D. Nixon MA

Walsall College of Technology St. Paul's Street, Walsall WS1 1XN Telephone: 25124 (3 lines).

EPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ad of Department:
D. HOMER, B.Sc.

BTEC FIRST CERTIFICATE IN ENGINEERING

The course consists of a coherent scheme of unitised study in which the student attempts 5 essential unit values, normally completed over 1 year, part time day and evening.

REF.	UNIT TITLE	CONTENT SUMMARY	% OF UNIT
F01	Engineering Fundamentals F. (2.0)	Safety at Work	5
		Hand and Machines processes) Fastening and joining materials) Works in plastics)	20
		Materials	10
		Engineering Drawing	20
		Electrical Measuring Instruments) Electrical Connection and Termination) Lighting and Power Circuits) Electrical Protection) Electronic Systems)	20
		Integrative Assignments	25
F02	Mathematics F (1.0)	Arithmetic	30
		Algebra	35
		Geometry and Trigonometry	25
		Statistics	10
F03	Science F (1.0)	Oxidation	10
		Statics	25
		Motion and Energy	35
		Electricity	30
F04	Information Technology Studies F. (1.0)	Introduction to Information Technology	10
		Computing	45
		Information Technology Applications	20
		Integrative assignments.	25

OPTIONS

REF.	UNIT TITLE	CONTENTS SUMMARY	% OF UNIT
F07	Introduction to Metals Technology F. (1.0)	Metallography	10
		Metal Micro/Macro Structure	5
		Mechanical Testing	10
		Metal Shaping Processes	15
		Cutting	10
		Forming Processes	10
		Joining by Welding	10
		Stiffening	10
		Integrative assignments	20
		OR	
F06	Engineering Drawing F (0.5)	Role and Production	10
		Geometrical Construction	5
		Engineering Drawing and Circuit Diagrams	60
		Integrative assignments	25
		AND	
F08	Microelectronic Systems F (0.5)	Basic Systems	10
		Analogue and Digital Signals and Systems	10
		Microprocessor Systems	20
		Hardware, Software and Programming	35
		Integrative assignments	25

Practical Modules

1F Mechanical and Production Workshop
2F Electrical and Electronic Workshop

WCT

Principal: J. Hicks MA
Director of Education: R. D. Nixon MA

Walsall College of Technology St. Paul's Street, Walsall WS1 1XN Telephone: 25124 (3 lines).

EPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ad of Department:
D. HOMER, B.Sc.

BTEC NATIONAL CERTIFICATE IN ENGINEERING

(ELECTRONIC ENGINEERING)

he course consists of a coherent scheme of unitised study in which the student tempts 10 essential values, normally completed over 2 years, part time day and ening.

EF.	UNIT TITLE	CONTENTS SUMMARY	% of UNIT
E01	Mathematics NII (1.0)	Formulae and Laws	20
		Geometry and Trigonometry	30
		Algebra	30
		Calculus	20
E02	Engineering Applications of Computers NII (0.5)	Industrial Applications of Computers	9
		Computer Systems	13
		Utilities and Application Packages	9
		High and Low Level Languages	9
		Use of Computer Systems in Engineering	60
E03	Industry and Society N (0.5)	Industrial Relations	33⅓
		Consumers and Producers	33⅓
		Finance and Organisation	33⅓
E05	Electrical and Electronic Principles NII (1.0)	Circuit Theory	15
		Electric Fields and Capacitance	15
		Magnetic Fields	10
		Electromagnetism	15
		Alternating Voltages and Currents	15
		Single Phase a.c. Circuits	15
		Measuring Instruments and Measurements	15
E07	Electrical and Electronic Principles NIII (1.0)	Single Phase a.c. circuits	30
		Electrical Machines	5
		Circuit Theorems	15
		d.c. Transients	22
		Control Principles	18
		Measuring Instruments and Measurements	10
10	Electronics. NII (1.0)	Semiconductor Diodes	10
		Transistors	15
		Amplifiers	15
		Stablised Power Supplies	15
		Combinational Logic Gates	15
		Combinational Logic Networks	15
		Sequential Logic Systems	15

/Continued

EF.	UNIT TITLE	CONTENT SUMMARY	% of UNIT
E14	Electronics NIII (3.0)	Thyristor and other high power devices	10
		Controlled Rectification	3
		D.c. Line operation	3
		Unijunction Transistor Trigger Circuits	5
		d.c. Motor Control	3
		Fault Finding	20
		Decibels	2
		Amplifiers	10
		Oscillators	3
		Optic Fibres	5
		Pulse Waveforms	2
		Noise	2
		TTI, CMOS and ECL Gates	7
		Combinational Networks	7
		Sequential Systems	10
		Display Devices	3
		A - D and D - A Conversion Devices	5
E16	Microelectronic Systems N (2.0)	Microprocessor based Systems	15
		Instruction sets and machine code programs	10
		Stack and Interrupts	15
		Assembly Language programs	35
		Classification & Packaging of VLSI elements	15
		Signal Degradation	10

Principal: J. Hicks MA
Director of Education: R. D. Nixon MA

Walsall College of Technology St. Paul's Street, Walsall WS1 1XN Telephone: 25124 (3 lines).

EPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ead of Department:
D. HOMER, B.Sc.

BTEC NATIONAL CERTIFICATE IN ENGINEERING

ELECTRICAL AND ELECTRONIC ENGINEERING

The course consists of a coherent scheme of unitised study in which the student attempts 10 essential values, normally completed over 2 years part time day and evenings.

REF.	UNIT TITLE	CONTENTS SUMMARY	% of UNIT
NE01	Mathematics NII (1.0)	Formulae and Laws	20
		Geometry and Trigonometry	30
		Algebra	30
		Calculus	20
NE02	Engineering Applications of Computers NII (0.5)	Industrial Applications of Computers	9
		Computer Systems	13
		Utilities and Application Packages	9
		High & Low Level Languages	9
		Use of Computer Systems in Engienering	60
NE03	Industry and Society N. (0.5)	Industrial Relations	33⅓
		Consumers and producers	33⅓
		Finance and Organisation	33⅓
NE05	Electrical and Electronic Principles NII (1.0)	Circuit Theory	15
		Electric Fields and Capacitance	15
		Magnetic Fields	10
		Electromagnetism	15
		Alternating Voltage and Currents	15
		Single phase a.c. circuits	15
		Measuring Instruments and Measurements	15
NE08	Electrical and Electronic Principles NIII (1.0)	Single phase a.c. circuits	30
		Three phase circuits	15
		Circuit Theorems	15
		d.c. Transients	22
		Control Principles	8
		Measuring Instruments and Measurements	10
NE010	Electronics NII (1.0)	Semiconductor Diodes	10
		Transistors	15
		Amplifiers	15
		Stabilised Power Supplies	15
		Combinational Logic Gates	15
		Sequential Logic Systems	15
		Combinional Logic Networks	15

/Continued

REF.	UNIT TITLE	CONTENTS SUMMARY	% of UNIT
NE013	Electronics NIII (1.0)	Thyristors & other high power devices	30
		Controlled Rectification	15
		d.c. Line operation	10
		Unijunction Transistor Trigger Circuits	15
		d.c. Motor Control	15
		Fault Finding	15
NE015	Microelectronic Systems NII (1.0)	Microprocessor based systems	30
		Instruction sets and machine code programs	20
		Stack and Interrupts	30
		Assembly Language programs	20
NE017	Electrical Applications NII (1.0)	Supply, transmission & Distribution	30
		Materials	25
		Transformers	10
		Illumination	15
		Switchgear and Protection	5
		Measurements and Fault Diagnosis	15
NE18	Electrical Applications NII (2.0)	Transformers	10
		d.c. machines	10
		Synchronous machines	10
		Induction motors (and small control motors)	20
		Power drive Transmission	7
		Eletroheat	20
		Measurements and Fault Diagnosis	8

Principal: J. Hicks MA
Director of Education: R. D. Nixon MA

WCT

Walsall College of Technology St. Paul's Street, Walsall WS1 1XN Telephone: 25124 (3 lines).

EPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

ead of Department:
D. HOMER, B.Sc.

BTEC NATIONAL DIPLOMA IN ENGINEERING

(ELECTRICAL AND ELECTRONIC ENGINEERING)

The course consists of a coherent scheme of unitised study in which the student attempts 18 essential values, normally completed over 2 years full time.

REF.	UNIT TITLE	CONTENTS SUMMARY	% of UNIT
NE01	Mathematics NII (1.0)	Formulae and Laws	20
		Geometry and Trigonometry	30
		Algebra	30
		Calculus	20
NE02	Engineering Applications of Computers NII (0.5)	Industrial Applications of Computers	9
		Computer Systems	13
		Utilities and Application Packages	9
		High and Low Level Languages	9
		Use of Computer Systems in Engineering	60
NE04	Industry and Society N. (1.0)	Industrial Relations	20
		Consumers and Producers	20
		Finance and Organisation	20
		Industry and Change	20
		National and Regional Industrial Policies	20
NE05	Electrical and Electronic Principles NII (1.0)	Circuit Theory	15
		Electric Fields and Capacitance	15
		Magnetic Fields	10
		Electromagnetism	15
		Alternating Voltages and Currents	15
		Single phase a.c. Circuits	15
		Measuring Instruments and Measurements	15
NE06	Electrical and Electronic Principles NIII (1.5)	Single phase a.c. Circuits	20
		Three Phase Circuits	12.5
		Circuit Theorems	12.5
		d.c. Transients	15
		Control Principles	15
		Information Transmission	15
		Measuring Instruments and Measurements	10
NE10	Electronics NII (1.0)	Semiconductor Diodes	10
		Transistors	15
		Amplifiers	15
		Stabilised Power Supplies	15
		Combinational Logic Gates	15
		Combinational Logic Networks	15
		Sequential Logic Systems	15

/Continued

REF.	UNIT TITLE	CONTENTS SUMMARY	% OF UNIT
NE14	Electronics NIII (3.0)	Thyristor and other high power devices	10
		Controlled Rectification	3
		d.c. Line Operation	3
		Unijunction Transistor Trigger Circuits	5
		d.c. motor Control	3
		Fault Finding	20
		Decibels	2
		Amplifiers	10
		Oscillators	3
		Optic Fibres	5
		Pulse Waveforms	2
		Noise	2
		TTI, CMOS and ECL Gates	7
		Combinational Networks	7
		Sequential Systems	10
		Display Devices	3
		A - D and D - A Conversion Devices	5
NE16	Microelectronic Systems N. (2.0)	Microprocessor based systems	15
		Instruction sets and machine code programs	10
		Stack and Interrupts	15
		Assembly Language programs	35
		Classification & packaging of VLSI elements	15
		Signal Degradation	10
NE17	Electrical Applications NII (1.0)	Supply, Transmission and Distribution	30
		Materials	25
		Transformers	10
		Illumination	15
		Switchgear and Protection	5
		Measurements and Fault Diagnosis	15
NE18	Electrical Applications NIII (2.0)	Transformers	10
		d.c. machines	10
		Synchronous machines	10
		Induction Motors (and control motors)	20
		Switchgear and Protection	15
		Power drive transmission	7
		Electroheat	20
		Measurements and Fault Diagnosis	8
NE24	Project N (1.0)	Design OR	
		Design and Make OR	
		Investigational OR	
		Redesign and Modification OR	
		Comparison OR	
		Instrumentation	
		Problem Identification	10
		Information Seeking and Analysis	10
		Problem Consideration and Solution	20
		Implementation	30
		Review and Report	30

/Continued

OPTIONS

REF.	UNIT TITLE	CONTENTS SUMMARY	% OF UNIT
NE23	Mathematics NIII (2.0)	Number Systems (including Complex)	5
		Algebra	15
		Calculus	30
		Geometry and Trigonometry	50
		AND	
NE22	Industrial Control and Instrumentation NIII. (1.0)	Control System Elements	5
		Transducers	20
		Signal Conditioning	10
		Controllers	10
		Actuators	10
		Indicating and Recording Devices	30
		Control and Instrumentation Systems	15
		OR	
NE21	Digital System Fault Finding NIII (1.0)	Faults in Digital and Computer Systems	15
		Equipment used in Fault Finding	10
		Location of faults in digital and computer systems	35
		Fault local assignments	40
		ALTERNATIVELY	
NE19	Software Design Methods N (2.0)	Software in real-time applications	10
		Program methodology and design	15
		Strucuture programming for real-time applications	5
		Structured programming	20
		Program implementation	40
		Program identification	10
		AND	
NE20	Microprocessor Interfacing NIII (1.0)	Interface concepts	20
		Interface implementation	20
		System implementation	60

Practical Modules

1 NE Electronics Workshop
2 NE Mechanical and production Workshop
3 NE Microprocessor/Computing Workshop
4 NE Electrical Workshop.

APPENDICES 4

NEW PATTERN OF HIGHER NATIONAL CERTIFICATE COURSES

WALSALL COLLEGE OF TECHNOLOGY

ELECTRONICS SECTOR

BTEC HIGHER NATIONAL CERTIFICATE
IN ELECTRONICS SCHEME OF UNITS.

MATHEMATICS NIII	(1.0 UNIT)
ELECTRICAL PRINCIPLES H	(1.0 UNIT)
ANALOGUE ELECTRONICS H	(2.0 UNITS)
DIGITAL ELECTRONICS H	(2.0 UNITS)
MICROELECTRONIC SYSTEMS H	(2.0 UNITS)
PROJECT H	(1.0 UNIT)
INDUSTRY AND COMMUNICATIONS	(1.0 UNIT)

BTEC HIGHER NATIONAL CERTIFICATE IN (ELECTRICAL WITH ELECTRONIC APPLICATIONS) ENGINEERING

REF.	UNIT TITLE	CONTENTS SUMMARY
HE01	Mathematics NIII (1.0)	1. Complex Numbers (Cartisian and Polar Form) 2. Matrices and Determinants Algebra. 3. Exponential series. 4. Trigonometry (Waveforms, Compound angle formulae) 5. Differential Calculus (Sums, products and quotient rules, Maximum Minimum rules. 6. Integral Calculus (Trigonometrical and exponential functions.) (Boundary limitations). 7. Solution of 1st order Differential Equations. 8. Statistics (Mean, median, mode, deviation.)
HE02	Industrial Studies H (1.0)	1. Estimating and Tendering 2. Contract documentation. 3. Forward Planning 4. Finance and Accounts. 5. Marketing 6. Management of Personnel.
HE03	Electrical & Electronic Principles H (1.0)	1. Complex analysis of single phase circuits. 2. Circuit Theory 3. Complex waveforms 4. Power Transmission Lines 5. Unbalanced 3-phase Load analysis. 6. Energy Transfer (Electro-Thermal-Mechanical transfer). 7. Properties of Conducting, Magnetic and dielectric materials).
HE04	Distribution of Electrical Energy H. (1.0)	1. Switchgear. 2. Symmetrical and Asymmetrical Faults. 3. Earthing. 4. Industrial Distribution systems. 5. Protection relays and devices. 6. Testing.
HE05	Electrical Engineering Services. H. (1.0)	1. Artificial lighting systems. 2. Air conditioning systems. 3. Refrigeration plant. 4. Indirect resistance heating. 5. Direct resistance heating 6. Induction heating. 7. Dielectric heating 8. Microwave heating. 9. Energy Management.

REF.	UNIT TITLE	CONTENTS SUMMARY
HE06	Project H. (1.0)	As far as practical, this Project unit will be related to the industrial activity in which the student is involved. Typical project may be 1. Design. 2. Design and make. 3. Investigational. 4. Redesign and modify. 5. Comparisons. 6. Instrumentation. Etc.
HE07	Electrical Machines H. (1.0)	1. 3 phase transformers. 2. 3 phase induction motors and control. 3. Synchronous machines and control. 4. Drive Dynamics and control.
HE08	Power Control Systems H. (1.0)	1. Control system theory. 2. Stability of Control systems. 3. Speed Control Systems. 4. Position Control Systems. 5. Temperature Control Systems. 6. Level Control Systems. 7. Flow Control Systems.
HE09	Microelectronic Applications H. (1.0)	1. System specifications. 2. Transducers, sensors and actuators. 3. Interfacing. 4. Microcomputer Control. 5. Programmable Logic Control. 6. Fault Diagnosis.
HE10	Measurements and Testing H. (1.0)	1. Philosophy of Testing and Measurement. 2. Use of basic test equipment. 3. Specialist measuring equipment. 4. Data processing. 5. Test procedures.

APPENDICES 5

TYPICAL NATIONAL CERTIFICATE NEW

STANDARD UNIT

Business & Technician Education Council

Unit Number
U86/329

Standard Unit

Unit title	Electrical and Electronic Principles
Value	As a guide, it is estimated that the material included in the bank is equivalent to three units (3.0).
Learning support time	The whole, therefore, represents 180 hours of study in respect of a part-time course (where it is complemented by work-based experiential learning) with up to 270 hours in full-time courses.
Level	N

Prerequisites	Mathematics F, Science F *or* GCE '0' level Mathematics, Physics for NII objectives. Appropriate NII objectives in Mathematics and Electrical and Electronic Principles for NIII objectives.
Co-requisites (to be studied in parallel)	None
Exemptions	None

Summary of aims

Users must formulate and list aims appropriate to the combination of material selected and in relation to other units and the aims of the programme.

Teaching/learning strategies

1 A practical investigative approach to learning should be adopted wherever appropriate. Prediction of performance followed by evaluation of and comparison with results of practical tests is to be preferred to the sterile 'verification' of well known laws.

2 The relevance of material from this unit to the technological units which it supports should be stressed.

3 *Measuring Instruments and Measurements*
Principal objective 22 is compulsory in all NII Level and Principal objective 23 is compulsory in all NIII Level units built up from this bank. If material from the bank is integrated with other technological units, *sections 22* and *23* must be included.

It is expected that, as a rule, sections *22* and *23* will be fully integrated with other material selected. Practical measurement skills, good practice and correct use of instruments should be emphasised and a clear distinction should be drawn between accuracy, precision and resolution.

4 *Circuit Theory*
It is expected that, although *section A* will normally be introduced in relation to d.c., its application to a.c. circuits will also be illustrated following completion of the necessary prerequisite objectives.

BTEC/ND (Elect + E'nic) College Ref. N06

B/TEC
Business & Technician
Education Council

Unit Number
U86/329

Unit Title ELECTRICAL AND ELECTRONIC PRINCIPLES

Value 1.5

Level N III

Special Notes 1. The content for this unit together with relevant learning support time is detailed below.

2. The content used is

*delete as applicable

*~~(a) a standard unit/an amended version of the standard unit~~.

*(b) an amended version extracted from the identically titled standard bank of objectives.

IDENTI-FICATION LETTER	TITLE OF SECTION	PRINCIPLE OBJECTIVE No.	SPECIFIC OBJECTIVE LETTERS	LEARNING SUPPORT TIME %
F	Single Phase A.C. Circuits	9	1 - m	)
		10	a - 1	) 20%
		11	a - c	)
G	Three-phase Circuits	12	a - i	12.5%
H	Circuit Theorems	13	a - q	12.5%
I	D.C. Transients	14	a - h	15%
K	Information Transmission	16	a - h	)
		17	a - f	) 15%
M	Control Principles	19	a - e	)
		20	a - d	) 15%
		21	a - f	)
N	Measuring Instruments & Measurements	23	a - i	) 10%
Assessment: 50% Unit/Integrative Assignments				
	50% End of Unit test			

Teaching/learning strategies

5 *Electric Fields and Capacitance/Magnetic Fields*
With reference to *sections B* and *C*, it is expected that analogies will be drawn between corresponding electric and magnetic field parameters. The analogy may be extended to conduction fields for the more advanced student if time permits.

6 *Magnetic Fields and Electromagnetism*
The approach to *sections C* and *D* could be substantially investigative, centred round tests on a ferromagnetic core wound with one or more coils.

7 *Single-phase A.C. Circuits*
Either a phasor diagram/trigonometrical approach or a j-operator approach may be used in *section F*. If the latter approach is adopted, it is expected that it be non-mathematical, treating j merely as an operator which rotates phasors by 90°, unless the appropriate mathematical underpinning has been well established.

8 *D.C. Transients*
It is expected that the student should be familiar with the derivation of the equations for exponential growth and decay but that he/she should *not* be required to reproduce the proofs.

9 *Electrical Machines*
Section J should be selected unless it is to be covered by similar objectives elsewhere. Teaching/learning should emphasise performance of tests and evaluation of results. Students should be introduced to the potential for modifying inherent characteristics presented by modern electronic drives.

Assessment scheme

1 A minimum of 30% of the assessment should be based on practical laboratory and/or assignment work.

2 The assessment of principal objectives 22 and 23 *Measuring Instruments and Measurements* should be almost entirely by practical activity.

Objectives 22 and 23 may be assessed as discrete objectives or their assessment may be integrated with the assessment of other objectives.

3 It is expected that the student will report a proportion of his practical activity by formal and informal, written and oral means. This may provide a basis for the assessment of practical skills and of communications skills. However, as far as is possible, evaluation of these two activities should be decoupled, as should the resulting feedback to the student.

Special notes

1 This unit comprises a bank of material from which centres may select principal objectives and associated indicative objectives as required.

2 The material may be packaged as discrete units (half, single or double) or may be integrated into other centre-devised technical units as required. In either case, choice of material must be reflected in the unit aims and in the assessment analysis.

3 In selecting material to meet course specifications it may be helpful to note the ascribed levels:

NII Level	Objectives 1, 2, 3, 4, 5, 6, 7, 8, 9, 16, 17, 19, 22.
NIII Level	Objectives 10, 11, 12, 13, 14, 15, 18, 20, 21, 23.

Special notes

Material at differing levels may be aggregated to form N Level units but the interests of students aspiring to entry to higher education may be best served in the short term by a clear distinction being drawn between units formed of objectives substantially at NII Level and units formed of objectives substantially at NIII Level.

4 Centres are required to indicate the approximate learning support time required for each major section of material selected.

Section	Principal Objectives plus indicative content or specific objectives
A Circuit theory	1 Applies circuit theory to the solution of simple circuit problems. a Applies Ohm's Law to the solution of problems relating to series-parallel combinations of resistors. b Derives and applies the concept of proportional voltage and current division in circuit analysis. c Applies Kirchhoff's Laws to problems involving not more than two unknowns.
B Electric fields and capacitance	2 Applies the fundamental laws and properties of electric fields to problems involving capacitors. a Introduces the concepts of electric field and electric flux to explain the forces of attraction and repulsion between charged bodies and defines electric field strength, potential and potential difference in terms of force and work done on a unit charge. b Expresses field strength in terms of potential gradient. c Establishes the relationship between electric field strength and electric flux density and defines relative permittivity and permittivity of free space. d Defines capacitance as the constant of proportionality between charge and potential difference and establishes the relationship between capacitance and the physical dimensions of a pair of parallel plates. e Derives expressions for energy stored by a capacitor. f Solves problems relating to uniform fields in single dielectrics involving the relationships established in *a* to *e*. g Deduces expressions for the equivalent capacitance of capacitors connected in series and parallel, solves simple problems and compares predicted and measured values for series and parallel capacitor combinations. h Identifies and distinguishes between capacitors of differing construction and characteristics and relates dielectric strength to working voltage.
C Magnetic fields	3 Applies the fundamental laws governing magnetic fields to the solution of problems relating to magnetic circuits and materials. a Introduces the concept of the magnetic field and magnetic flux to explain the forces of attraction and repulsion between magnetised bodies and defines magnetic field strength. b Establishes the relationship between magnetic field strength and magnetic flux density and defines relative permeability and the permeability of free space.

C Magnetic fields

c Investigates the effect of the core material on the performance of an electromagnet, compares magnetisation characteristics of typical ferromagnetic materials obtained by measurement, and deduces the range of values of relative permeability.

d Relates magnetomotive force, reluctance and magnetic field strength and solves problems involving magnetic circuits having not more than a single change of dimension, material or air-gap using data from magnetisation curves.

e Displays hysteresis loops on a CRO and observes the effects of variation of magnetic material and magnetic field strength.

f States that hysteresis loss is proportional to the area of the loop and explains the importance of hysteresis loss for a.c.-excited devices.

D Electromagnetism

4 Applies the fundamental principles of, and laws governing electromagnetic induction.

a Explains the motor principle in terms of the interaction between a magnetic field and a current-carrying conductor and applies the relationship $F = Bli$ to simple situations.

b Observes the production of induced voltage and describes it as due to change in flux linkage.

c Establishes the relationships $E = Blv$ and $E = N \frac{d\phi}{dt}$

and uses them to solve simple problems.

d Explains the historical and technical significance of Faraday's and Lenz's Laws.

e Describes the concept of eddy currents and eddy current loss, explaining their significance under conditions of a.c. magnetisation.

5 Understands the concepts of self- and mutual-inductance and relates these to the transformer principle.

a Defines self-inductance of a coil in terms of the proportionality of flux linkages and current in a linear magnetic medium and describes the production of induced voltage due to change in flux linkages.

b Deduces and applies the relationship $L = \frac{N^2}{S}$ and $E = L\frac{di}{dt}$

c Defines mutual inductance and describes the production of induced voltage due to change of mutual flux linkage.

d Describes the transformer principle in terms of Lenz's Law and induced volts per turn, deducing the effect of turns ratio on voltage ratio.

e Deduces that energy stored in an inductor is $\frac{1}{2}LI^2$.

f Solves problems on self-inductance, mutual inductance and the transformer principle.

E Alternating voltage and currents

6 Displays waveforms and determines the main parameters used to describe and measure them.

a Defines the terms amplitude, period, frequency, instantaneous, peak-to-peak, r.m.s., average in relation to alternating (sinusoidal and non-sinusoidal) and unidirectional waveforms and uses an oscilloscope to display and measure these parameters.

b Defines form factor and determines the approximate average and r.m.s. value of given sinusoidal and non-sinusoidal waveforms.

7 Uses phasor and algebraic representation of sinusoidal quantities.

a Defines a phasor quantity.

b Determines the resultant of the addition of two sinusoidal voltages by graphical and phasor representation.

c Explains the phase-angle relationship between two alternating quantities.

d Defines a sinusoidal voltage in the form
$v = V_m \sin(\omega t + \phi)$.

e Determines current from the application of sinusoidal voltage to a resistive circuit.

f Interrelates graphical, phasor and algebraic representation in the determination of amplitude, instantaneous value, frequency period and phase of sinusoidal voltage and currents.

g Determines power in an a.c. resistive circuit from given data.

8 Relates the concepts of a.c. theory to an elementary treatment of half- and full-wave rectification.

a Defines the elementary principles of half- and full-wave rectification as the conversion from alternating to uni- directional voltage by the application of simple switching.

F Single phase A.C. circuits

9 Uses a.c. circuit theory to solve simple series a.c. circuit problems.

a Draws the phasor diagrams and related voltage and current waveforms for circuits comprising:

- pure resistance
- pure inductance
- pure capacitance.

b Describes inductive reactance and capacitive reactance in terms of impeding the flow of an alternating current and uses basic relationships to solve simple problems.

c Draws phasor diagrams corresponding to L-R and C-R series circuits.

d Defines impedance as $Z = V/I$.

F Single phase A.C. circuits

e Derives impedance triangles from voltage triangles and shows that $Z^2 = R^2 + X^2$ and that Tan ϕ = X/R, Sin ϕ = X/Z and Cos ϕ = R/Z.

f Applies equations in *d* and *e* to the solution of single branch L-R and C-R series circuits at power and radio frequencies.

g Shows graphically that where currents and voltages are sinusoidal:

- for a purely resistive a.c. circuit, average power is VI
- for a purely reactive a.c. circuit, average power is zero
- for a resistive/reactive a.c. circuit, average power depends upon phase angle.

h States that P = VI Cos ϕ for sinusoidal waveforms.

i Derives the power triangle from the voltage triangle and identifies true power (P), apparent power (S) and reactive voltamperes (Q).

j Defines power factor as true power/apparent power and show that where V and I are sinusoidal, power factor = Cos ϕ.

k Explains that power dissipation in series L-R and C-R a.c. circuits is I^2R.

l Uses phasor diagrams to solve simple series L, C and R a.c. circuits.

m Defines series resonance as occurring when the supply voltage and current are in phase and sketches a phasor diagram showing that:

- V = V at resonance
- V and V may be much greater than the supply voltage.

10 Applies a.c. circuit theory to the solution of parallel network problems including resonant conditions.

a Draws the phasor diagram for a 2-branch parallel circuit with C in one branch and only

- L
- L-R
- R

in the other branch.

b Determines the current in each branch of the circuit in *a* and determines the sum of the branch currents.

c Determines the impedance of the circuit referred to in *a* and the voltage, current and phase angle.

d States the conditions for resonance in a parallel circuit with L and R in one branch and C only in the other.

e Derives and applies the formula for the frequency of series resonance.

F Single phase A.C. circuits

f Applies the exact and approximate formulae for the parallel resonance frequency.

g Defines Q-factor as the voltage magnification in a series circuit and as the current magnification in a parallel circuit.

h Determines the power dissipated in simple series and parallel circuits.

i Corrects the power factor of a given circuit to unity and explains why this might be desirable in practice.

j Explains the use of resonant circuits to select and amplify signals.

k Measures and sketches response curves of tuned circuits.

l Measures bandwidth and explains the effect of variation of component values upon bandwidth.

11 Understands the function of simple filter and attenuation circuits and measures steady-state response to an a.c. input.

a Defines attenuation and the decibel.

b Describes the function of the following circuits:

- high pass
- low pass
- band pass
- band stop.

c Measures the response of simple L, C and R filter circuits and of simple resistive attenuation circuits.

G Three-phase circuits

12 Applies the basic theory of balanced three-phase circuits to the solution of problems.

a Describes the nature of, and explains the reasons for a three-phase supply network, with reference to the National Grid distribution system.

b Explains the need for star and delta connections for power distribution and distinguishes between delta and star (3- and 4-wire) methods of connection.

c Uses the basic relationships between line and phase quantities under balanced conditions to solve simple problems.

d Explains that the power dissipation in a three-phase load is the sum of the single-phase powers and that the power in a balanced three-phase load is $\sqrt{3}\, V_{LINE}\, I_{LINE} \cos \phi$.

e Measures power in balanced and unbalanced three-phase loads using 1, 2 and 3 wattmeters and uses the two-wattmeter method to estimate power factor of a balanced load.

f Shows by phasor diagrams that the sum of line or phase currents in a balanced system is zero.

G Three-phase circuits

g Draws phasor diagrams to explain positive and negative phase sequence.

h Calculates neutral current in a simple unbalanced 4 line system.

i Shows by phasor diagrams that circulating voltage is twice line voltage in an incorrectly closed Delta system and explains the practical significance of the result.

H Circuit theorems

13 Applies circuit theorems to the solution of d.c and a.c. circuit problems.

a Applies the Principle of Superposition to the solution of circuit problems.

b Explains the ideal concepts of constant current and constant voltage sources.

c Deduces constant current and constant voltage equivalent circuits for practical sources and converts from one type of equivalent circuit to the other.

d Solves simple problems using Thevenin's and Norton's theorems.

e Applies simple circuit-reduction techniques.

f Applies the maximum power transfer theorem for resistive loads and gives examples of practical sources to which the maximum power transfer theorem is applicable.

g Derives the turns relationship for transformer matching and applies it to problems.

I D.C. transients

14 Predicts transient behaviour of simple L-R and C-R circuits.

a Explains how the current and capacitor voltage in a series C-R circuit which is connected to a d.c. source vary with time.

b Sketches the curves for the variation of voltage and current with time for each of the components in a series C-R circuit when the capacitor is:

- charging
- discharging.

c Defines the time-constant of series C-R and L-R circuits.

d Predicts the growth and decay of the component voltage or current in a series C-R circuit after the commencement of:

- charging
- discharging

and compares with measured values.

e Explains the growth and decay of current and voltages in a series L-R circuit.

I D.C. transients

f Sketches curves for the variation of voltage and current with time for each of the components in a series L-R circuit after the circuit has been:

- connected to
- disconnected from

a d.c. supply.

g Calculates the component voltage or current in a series L-R circuit after the circuit has been:

- connected to
- disconnected from

a d.c. supply.

h Demonstrates the effect of circuit time constants on rectangular waveforms using an oscilloscope and relates waveforms to simple concepts of integration and differentiation.

J Electrical machines

15 Understands the principles of rotating machines and evaluates their characteristics.

a Explains that:

- motors convert electrical energy into mechanical energy
- generators convert mechanical energy into electrical energy and explains how $E = Blv$ and $F = Bli$ apply to both motors and generators.

b Labels on a given diagram the essential parts of a d.c. machine and describes with the aid of diagrams the rectifying/inverting action of a simple commutator.

c Explains that the relationships:

- $E = k_e N\phi$
- $T = k_t I_a \phi$
- $E = V \pm$ (internal volt drop)

apply to motors and generators and solves problems using these equations.

d Lists and explains the principal losses of machines, performs tests to determine losses and calculates efficiency.

e Sketches and explains the idealised load characteristics for shunt and series wound d.c. motors and generators using the equations of *c* above. Compares sketches with characteristics obtained from tests.

f Explains the need for and uses a d.c. motor starter.

g Identifies d.c. motors as variable speed machines and operates motors on load over a range of speeds.

J Electrical machines

h Describes how a symmetrical polyphase supply applied to a symmetrical polyphase winding produces a resultant travelling field of uniform magnitude and explains how a rotating field induces current in conducting rotor and produces torque in an induction motor.

i Performs a load test on a 3-phase induction motor and explains why slip increases with load.

j Explains the principle of stepping motors.

K Information transmission

16 Understands how electrical signals convey information.

a Appraises the systems and media available for the transmission of information by electrical means, eg radio, television, telephone.

b Explains the difference between d.c. and a.c. signals.

c States the practical applications and limitations of d.c. signals.

d Identifies the following terms in relation to d.c. and a.c. signals by reference to waveforms displayed on a CRO:

- frequency
- amplitude
- wavelength
- period
- velocity
- digital
- analogue
- modulated
- complex.

e Explains the information-carrying properties of frequency and amplitude.

f Explains and demonstrates the relationship between sound waves and analogue electrical signals.

g Explains and demonstrates the relationship between digital information and its digital electrical signal.

h Uses a carrier to convey information.

17 Understands the principles of digital information transmission.

a Contrasts the basic characteristics of analogue and digital transmission systems with respect to signal/noise ratio and explains why unmodified digital data cannot be transmitted directly over an analogue transmission system.

b Describes the data formats of digital transmission as:

K Information transmission

- serial
- parallel.

c Describes the two forms of serial transmission as:

- asynchronous
- synchronous.

d Describes the features of a typical protocol for:

- asynchronous transmissions eg RS232
- synchronous transmission eg HDLC.

e Describes typical data network configurations:

- ring
- star
- mesh
- tree.

f Describes features of:

- local area networks
- wide area networks.

L Modulation

18 Understands amplitude, frequency, phase and pulse modulation.

a Describes modulation as the process of superimposing information on a carrier.

b States that modulation is a process whereby some characteristics of a carrier wave are varied by another wave.

c States the relationship between baseband signal and carrier frequency.

d Displays waveforms of and identifies:

- a modulated carrier
- an amplitude modulated carrier
- a frequency modulated carrier
- a pulse modulated carrier
- a phase modulated carrier.

e Draws and labels pulse and sine-wave amplitude modulated waveforms.

f Explains the terms *modulation index* as applied to an AM waveform and observes the effect of overmodulation.

L Modulation

g States that de-modulation is the reverse process of modulation and demonstrates the process.

h States that frequency modulation is the technique of varying the frequency of a carrier wave and sketches an FM waveform.

i Compares an FM waveform with the waveforms of the unmodulated carrier and of the audio signal by reference to a CRO display.

j Explains the terms:

- frequency deviation
- frequency swing
- modulation index.

k Explains the function of a filter.

l Compares AM with FM in relation to:

- bandwidth
- power
- signal to noise ratio.

m Explains how phase modulation occurs when the phase of a carrier varies directly in proportion to the amplitude of a modulating signal.

n Explains how an analogue signal can be transmitted as a series of pulses without loss of information and displays a pulse-modulated signal.

o Shows how pulse-modulated signals can be coded and transmitted as pulse-code modulated signals.

M Control principles

19 Compares the performance of simple open-loop and principles closed-loop control systems and predicts the effect of system parameters on system behaviour.

a Selects an example of a control system employed in:

- an engineering situation
- a non-engineering situation

and explains its purpose and operation.

b Defines and compares the advantages and disadvantages of open-loop and closed-loop control systems, referring to practical examples eg temperature control.

c Derives the closed-loop transfer-function of a simple control system, ignoring the effects of the component time constants.

d Appraises the causes and problems of instability in closed-loop systems, referring to practical examples.

M Control principles

e Observes the transient and steady-state behaviour of simple first-order systems and investigates the effect of gain and time constant on system response.

20 Explains qualitatively the effect of commonly-used control strategies on the behaviour of a second-order control system.

a Observes the behaviour of an underdamped second order control system and determines its steady-state and transient performance.

b Investigates the effect of damping ratio on system response, referring to underdamped, overdamped and critically damped systems.

c Draws a block diagram of a simple control system, identifying transducers, controller, actuators and plant and describing the function of each.

d Explains the use of:

- proportional control
- proportional + integral control
- proportional + integral + derivative control

and describes the improvement in system performance which results in each case.

21 Understands how commonly-used control strategies can be implemented by analogue and digital means.

a Explains how operational amplifiers can be used to implement the three control laws in *20*.

b Explains how a digital computer can be used to implement the three control laws in *20*.

c Assesses the advantages and disadvantages of using a digital computer as a controller.

d Describes how the control laws of *20* can be implemented in the computer software.

e Assesses the problems that can occur when processes are controlled by computer and identifies the requirements for sampling the system variables.

f Describes examples of systems in which multiplexing is used to allow computer-control of large numbers of variables.

N Measuring instruments and measurements

22 Understands the operation and limitations of measuring instruments and uses them correctly in a wide range of basic applications.

a Describes, with the aid of given diagrams, the principles of operation of moving coil instruments and explains the need for shunts and multipliers to extend the range of basic electrical indicating instruments.

b Uses ammeters and voltmeters correctly in d.c. circuit measurements.

N Measuring instruments and measurements

c Describes with the aid of diagrams the principles of operation of an ohm meter and uses an ohm meter for the measurement of resistance.

d Explains the need for rectifier instruments and states the frequency and waveform limitation inherent in moving coil rectifier instruments.

e Uses electronic and moving-coil multimeters correctly for the measurement of I and V in d.c. and a.c. circuits.

f Uses a wattmeter.

g Uses double beam CRO in direct and indirect measurement of a.c. and d.c. voltages and to measure period and frequency.

h Describes the principle of a null method of measurement.

i Describes with the aid of a diagram the principle of the Wheatstone bridge and uses a Wheatstone bridge to measure resistance over a wide range.

23 Assesses errors inherent in instruments and measurement methods and performs more complex measurements of electrical quantities.

a Makes dB measurements and explains the use of dB.

b Predicts and measures the loading effects and frequency characteristics of measuring instruments.

c Uses a CRO to demonstrate the presence of harmonics in various waveforms.

d Uses a CRO to measure sine, square and pulse waveforms and phase differences.

e Predicts and verifies the effect of distorted waveform on different detectors in electronic instruments and outlines the problems of interference to signal flow in a measurement system.

f Uses a commercial bridge for measuring inductance capacitance and Q-factor.

g Calculates simple errors due to the insertion of instruments.

h Calculates the power consumed in instruments and load and applies corrections where appropriate.

i Uses digital instruments to make measurements in digital circuits eg logic probe, logic analyser.

APPENDICES 6

TYPICAL HIGHER NATIONAL CERTIFICATE

NEW STANDARD UNIT

Business & Technician Education Council

Unit Number
13683B

BTEC-devised Unit

Unit title	Electronic Principles.
Value	1 . 0
Learning Support Time	Typically 60 hours in respect of a part-time course (where it is complemented by experience and learning at work) with up to 90 hours in a full time course.
Level	H

Prerequisites	Electrical and Electronic Principles NIII and appropriate Mathematics.
Co-requisites (to be studied in parallel)	None
Exemptions	None

Summary of aims

To develop students abilities to use Engineering Principles in the solution of engineering problems and applications through the systematic use of appropiate techniques for analysing, synthesising and evaluating.

Teaching and learning strategies

1 A practical investigative approach to learning should be adopted wherever appropriate. Prediction of performance followed by evaluation of and comparison with results of practical tests is to be preferred to the verification of well known laws.

2 The relevance of material from this unit to the technological units that it supports should be stressed.

3 Teaching staff should plan and coordinate the practical laboratory and/or assignment work for this unit with that for associated technological units. The practical work for this unit should be integrated with practical laboratory and/or assignment work in associated technological units where this can be done to advantage.

4 Complex Quantities - Section A provides the theoretical basis for a.c. techniques used in other sections. The concepts in Section A should be illustrated by practical work in later sections.

5 Circuit Theory and Two- Port Networks----Practical work illustrating the concepts in Sections B and C should be investigative.

Teaching and learning strategies

6 Complex Waveforms, and , Transmission Lines - Students should fully understand the derivation of the various equations and their implications, but should not be required to reproduce the proofs. The subject should be taught within the framework of electrical engineering practice, and a series of mathematical problems for their own sake be avoided. In all sections, practical work should illustrate theory.

7 The learning support time should be apportioned approximately:

Section A	10%
Section B	25%
Section C	10%
Section D	10%
Section E	10%
Section F	25%
Section G	10%

Assessment scheme

1. Assessment should reflect approximately the division of learning support time.
2. 50% of the assessment should be based on practical laboratory and assignment work.
3. A formal end-of unit test will be a component, accounting for 50% of the marks

Special Notes

1 In Section G, Principal Objective 14 is intended for students whose course needs are satisfied by the use of transmission line concepts to demonstrate the movement of signals in space and time. Principal Objective 15 is intended for those requiring a practical understanding of transmission lines and subsumes Objective 14.

2 In Section G Principle Objectives, it is not expected that the general transmission line equations should be derived. It is intended that the expressions for A to D should be deduced using a statement of the general equations as the starting point.

3 In objective 3f the package used may be for either matrix equation input or for circuit component and location input.

Section	Principal Objectives plus indicative content or specific objectives. The expected learning outcome is that the students:

A Complex Quantities

1 Apply complex notation in single phase a.c. series, parallel and series-parallel circuits.

a Calculate equivalent impedance and admittance of a.c. circuits in both rectangular and polar form.

b Apply sinusoidal voltage and current driving functions, in both rectangular and polar form to a.c. circuits and derive the appropriate responses.

c Calculate components for resonance and power factor correction.

d Calculate real, reactive and apparent power in a.c. circuits from parameters expressed in rectangular and polar forms.

B Circuit Theory

2 Apply circuit-theory techniques to the solution of a.c. circuit problems.

a Represent an energy source in its equivalent constant – voltage and constant – current generator forms and convert between each form.

b Prove the condition for maximum power transfer for resistive source and load, applying it to the solution of problems.

c Solve practical problems involving maximum power transfer for complex source and load where:

- resistance and reactance are independently variable
- impedance is variable at constant power factor.

d State theorems, develop techniques and solve circuit problems using eg:

- Thévenin's and Norton's theorems
- Star to Delta (T - π) and Delta-Star (π - T) networks
- Mesh and Nodal analysis
- Principle of Superposition.

3 Analyse the operation of magnetically coupled circuits.

a Define mutual inductance and deduces that:

$$e_2 = M\frac{di_1}{dt}, M = N_2\frac{d\phi_2}{di_1}, M = N_1\frac{d\phi_1}{di_2}, M = K\sqrt{L_1L_2}$$

where k is the coefficient of coupling.

b Describe the dot notation and deduce that, with a steady-state sinusoidal a.c. supply, $E_2 = \pm j\omega MI$.

c Deduce the values of secondary impedance coupled in series with the primary circuit where:

- $k < 1 : \frac{w^2 m^2}{Z_2}$
- a loss-free transformer is used: $\frac{N_p^2}{N_s^2} \; Z_L$

d Deduce equivalent circuits for a transformer that include the effects of resistive and reactive features.

e Solve problems that involve magnetically coupled circuits with complex loads, choosing and justifying the most appropriate circuit model.

f Design and perform experiments to test aspects of the circuit theory in a-e.

C Two Port Networks

4 Apply symmetrical two-port network models of active and passive networks to the solution of practical problems.

a Explain the basis and advantages of a symmetrical two-port model.

b Define the terms characteristic impedance and propagation coefficient, using an infinite number of networks, and illustrates that $Z_{in} = Z_o$ when $Z_L = Z_o$.

c Deduce and apply the relationships.

$$\frac{I_s}{I_R} = \frac{V_s}{V_R} = e^{\gamma} = e^{\alpha + j\beta} = e^{\alpha}\angle\beta$$

defining the neper and relating it to the dB.

d Define and determine insertion loss.

5 Design symmetrical attenuators.

a Draw circuit diagrams for T and π attenuators and derive expressions for R_o and α in terms of components.

b Design attenuators to specification.

D Complex Waveforms 6 Explain the nature of complex waveforms and solves circuit problems involving complex waves.

a Explain that the instantaneous value of a voltage for a complex wave is:

$$v = V_o + V_1 \sin(\omega t + \varnothing_1) + V_2 \sin(2\omega t + \varnothing_2) + ...$$

b Develop an expression for the instantaneous value of current flow in resistive, R-L, R-C and R-L-C circuits.

c Determine conditions for selective resonance and explain its uses and dangers.

d Determine the power dissipation in circuits of **b** above and defines power factor.

e Determine the r.m.s. value of a complex waveform.

f Explain how devices produce complex waveforms and why they may contain a limited range of harmonic components.

E Motion of Charged Particles in Electric and Magnetic Fields 7 Apply basic electron ballistics relationships.

a Determine the expression for the force experienced by a moving charge in:

- an electric field
- a magnetic field.

b Determine the path traced by a moving charged particle in:

- an electric field
- a magnetic field
- combined electric and magnetic fields.

c Apply the principles of **a** and **b** to the description of practical applications in the generation, deflection and focussing of electron beams.

F Transmission Lines 8 Use secondary constants to determine signal behaviour on correctly-terminated transmission lines.

a Determine expressions for Z_o and γ in terms of primary constants.

b Explain that $\gamma = \alpha \div j\beta$ and illustrate the effect of α and β on line performance.

c Deduce that the velocity (phase) of propagation of a signal along a line is given by ω.

d Deduce the conditions for a distortion-free line.

e Predict the circuit response of a matched line and compares with results from practical tests.

9 Determine signal behaviour on transmission lines terminated with a general impedance.

a Deduce the general transmission line equations in terms of distance and time.

b Develop the equations in a and deduce:

- expressions for Z_o, γ and velocity of propagation
- an expression for determining the magnitude and phase of a signal propagation along an infinite line
- the general solution of a line terminated with any impedance
- input impedance of a line terminated with a general impedance
- voltage and current at any point on a line terminated with a general impedance.

c Explain the essential characteristics of and determine relevant equations for:

- distortion-free
- loss-free
- low-loss
- low-frequency signal

transmission lines.

d Analyse mismatch on transmission lines and:

- determine voltage and current reflection and transmission coefficients
- explain the production of standing waves
- determine the voltage standing-wave ratio and positions along a line for maximum and minimum signal strength.

e Solve practical problems involving the concepts in **b**, **c** and **d**.

10 Demonstrate systems using loss-free transmission lines.

a Deduce an expression for a quarter wave-length transformer and explains its use in relation to eg:

- line supports
- rotating joints
- line-to-line matching.

b Deduce the conditions for stub matching.

G Properties of Magnetic and Dielectric Materials

11 Assess the magnetic properties of materials commonly used in electrical and electronic engineering.

a Categorise materials as:

- ferro-magnetic
- diamagnetic
- paramagnetic.

b Explain what is meant by hysteresis and eddy current losses in ferro-magnetic materials and describes the factors that influence their magnitude.

12 Assess the dielectric properties of materials commonly used in electrical/ electronic engineering.

a Assesses the suitability of a range of common dielectric and insulating materials in terms of eg:

- surface resistivity
- volume conductivity
- permittivity
- thermal characteristics
- mechanical characteristics.

b Explain in simple terms the physical basis of energy loss in dielectric materials and deduce an equivalent circuit model for a lossy capacitor.

c Use the model of **b** to explain the term loss angle, δ, and to deduce an expression for dielectric loss.

d Deduce how δ and dielectric loss vary with temperature and frequency.

APPENDIX 3

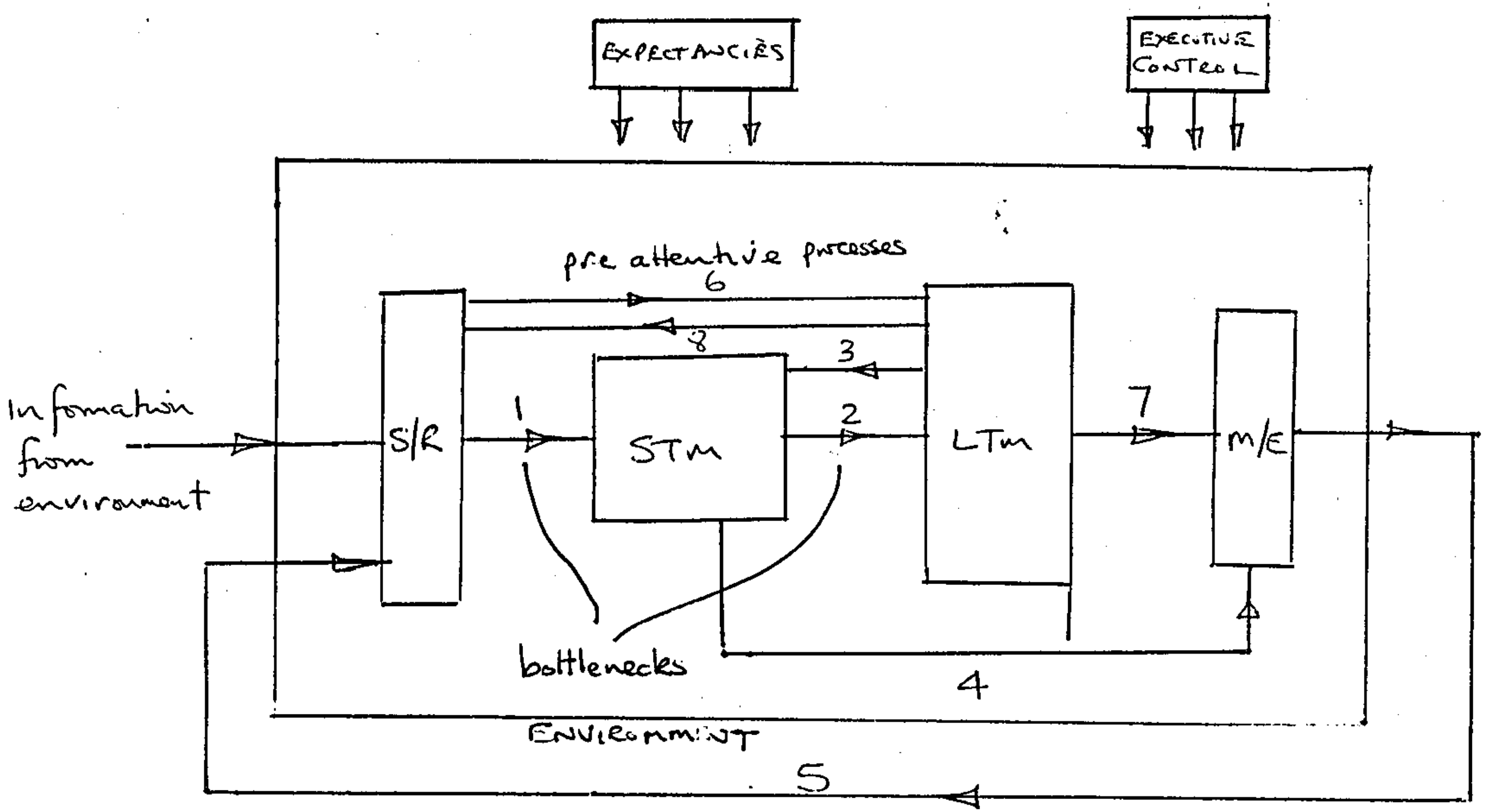
Period		Stage	Mental age range in years
Sensori-motor	I	Sensori-motor	0–2
Preparation for, and use of, concrete operations	II	Pre-operational	
		(A) Pre-conceptual	2–4
		(B) Intuitive	4–7
	III	Concrete operations	7–11½
Formal operations	IV	Formal operations	11½–

TABLE 3.1 - OUTLINE OF PIAGET'S STAGES OF DEVELOPMENT

Age	Characteristics
0 - 2 years	No internal thinking process. Recognises different objects.
2 - 4 years	Beginning of symbolic thought.
	Experimenting.
	Egocentric.
	Cannot handle multiple characteristics.
	Has concept of object.
4 - 7 years	More use of symbols.
	Concept of class and relation between classes.
7 - 11 years	Thought becomes more vigorous.
	Begins to generalise.
11 - 15 years	Abstract thinking.
	Ratio reasoning.
	Is spontaneously aware of his own thinking.
	Classification.
	Making deductions.
15 years	Can generalise to all situations.

The existence of a maturation unfolding of conceptual skills being linked with certain periods in the lives of children has an obvious bearing on curriculum planning.

TABLE 3.2 BORK'S CLASSIFICATION OF DEVELOPMENT



SR - sensory receptors
STM - short term memory
LTM - long term memory
ME = motor effectors.

FIGURE 3.1 - INFORMATION PROCESSING SYSTEM MODEL

A) STIMULUS -RESPONSE LEARNING
B) CHAINING (MEMORY ASSOCIATION } BASIC FORMS OF LEARNING

C) DISCRIMINATION
D) CONCEPT FORMATION
E) RULE LEARNING } INTELLECTUAL SKILL

F) PROBLEM SOLVING } COGNITIVE STRATEGIES

VERBAL INFORMATION LEARNING

MOTOR SKILLS

ATTITUDES

FIGURE 3.2 - GAGNE'S HIERARCHY OF LEARNING PROCESSES

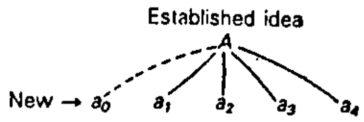
INTERNAL PROCESSES OF LEARNING
AND THE EXTERNAL INSTRUCTIONAL EVENTS
THAT MAY BE USED TO SUPPORT THEM

INTERNAL LEARNING PROCESS	EXTERNAL INSTRUCTIONAL EVENT
1. Alertness	1. Gaining attention
2. Expectancy	2. Informing learner of lesson objective
3. Retrieval to working memory	3. Stimulating recall of prior learning
4. Selective perception	4. Presenting stimuli with distinctive features
5. Semantic encoding	5. Guiding learning
6. Retrieval and responding	6. Eliciting performance
7. Reinforcement	7. Providing informative feedback
8. Cueing retrieval	8. Assessing performance
9. Generalizing	9. Enhancing retention and learning transfer

FIGURE 3.3 GAGNE'S INTERNAL PROCESSES OF LEARNING AND THE EXTERNAL INSRUCTIONAL EVENTS THAT MAY BE USED TO SUPPORT THEM

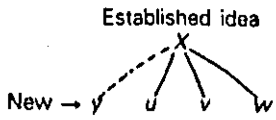
1. Subordinate Learning:

A. Derivative subsumption



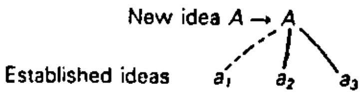
In derivative subsumption, new information a_0 is linked to superordinate idea *A* and represents another case or extension of *A*. The criterial attributes of the concept *A* are not changed, but new examples are recognized as relevant.

B. Correlative subsumption



In correlative subsumption, new information *y* is linked to idea *X*, but is an extension, modification, or qualification of *X*. The criterial attributes of the subsuming concept may be extended or modified with the new correlative subsumption.

2. Superordinate Learning:



In superordinate learning, established ideas a_1, a_2, and a_3 are recognized as more specific examples of new idea *A* and become linked to *A*. Superordinate idea *A* is defined by a new set of criterial attributes that encompass the subordinate ideas.

3. Combinatorial Learning:

New idea *A* → *B-C-D*

Established ideas *B* *C* *D*

In combinatorial learning new idea *A* is seen as related to existing ideas *B*, *C*, and *D* but is neither more inclusive nor more specific than ideas *B*, *C*, and *D*. In this case, new idea *A* is seen to have some criterial attributes in common with pre-existing ideas.

4. Assimilation Theory:

New information is linked to *relevant, pre-existing* aspects of cognitive structure and both the newly acquired information and the pre-existing structure are modified in the process. All of the above forms of learning are examples of assimilation. Most meaningful learning is essentially the assimilation of new information.

FIGURE 3.4 - FORMS OF MEANINGFUL LEARNING AS VIEWED IN ASSIMILATION THEORY

Meaningful learning	Clarification of relationships between concepts	Well designed audio-tutorial instruction	Scientific research (new music or architecture)
Intermediate meaningfulness	Lectures or most textbooks	School laboratory work	Most routine 'research' or intellectual production
Rote learning	Multiplication tables	Applying formulas to solve problems	Trial-and-error 'puzzle' solutions
	Reception learning	Guided discovery learning	Autonomous discovery learning

FIGURE 3.5 - AUSUBEL'S MATRIX MODEL OF LEARNING

APPENDIX 4

		Response Time	
		Low	High
Number of Errors	High	IMPULSIVE	
	Low		REFLECTIVE

TABLE 4.1 - RESPONSE TIME v ACCURACY

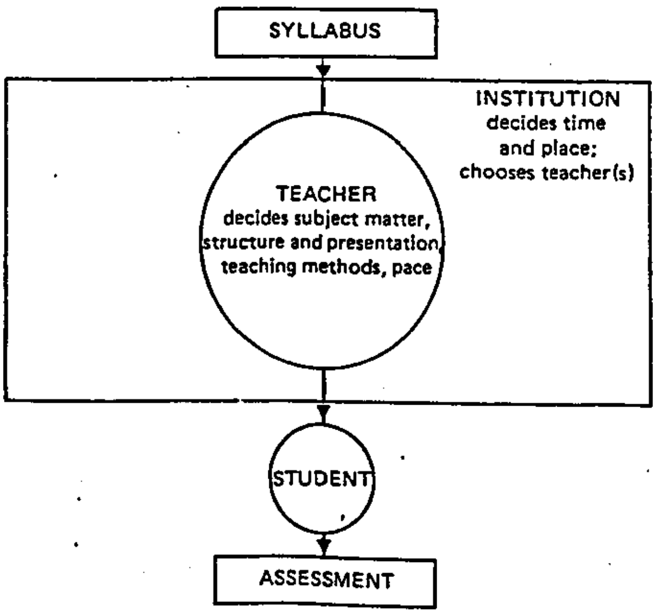


FIGURE 4.1 - THE STRUCTURE OF THE SYSTEM UNDERLYING THE TEACHER/INSTITUTION CENTRED APPROACH

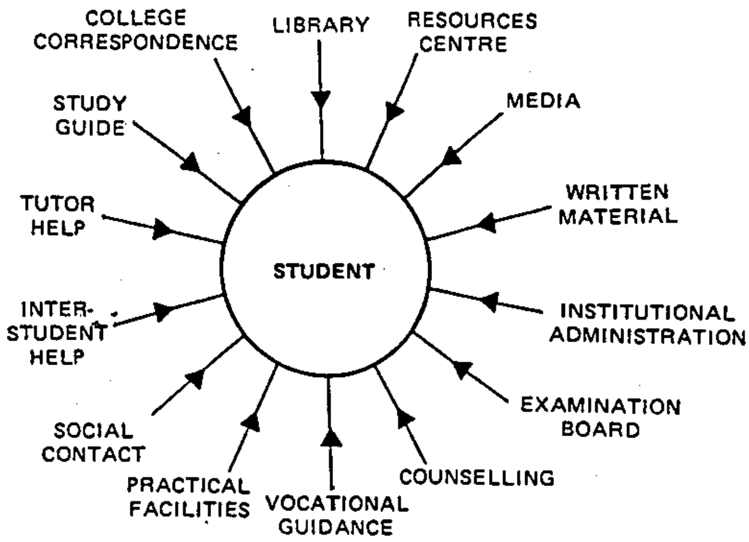


FIGURE 4.2 - THE STRUCTURE OF THE SYSTEM UNDERLYING THE STUDENT - CENTRED APPROACH

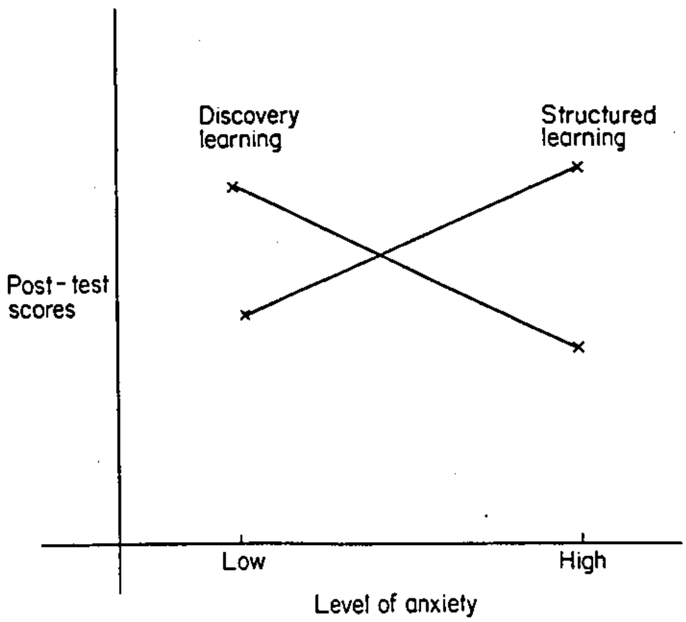


FIGURE 4.3 - EFFECTS OF ANXIETY ON PUPIL PERFORMANCE WITH CONTRASTING TEACHING STUDIES

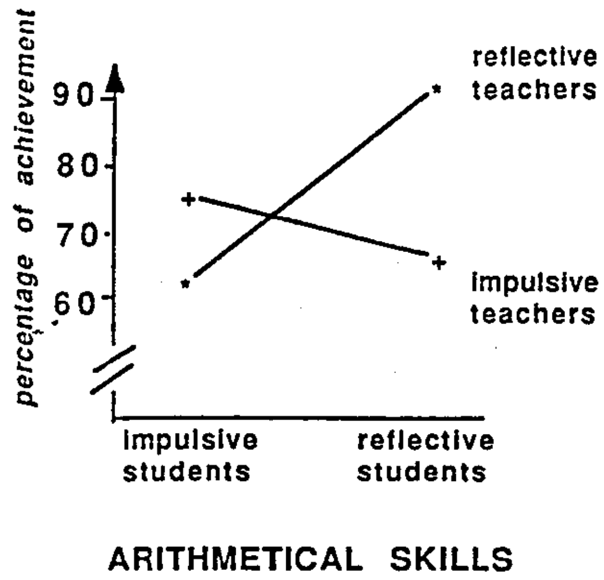


FIGURE 4.4 -ARITHMETIC SKILLS

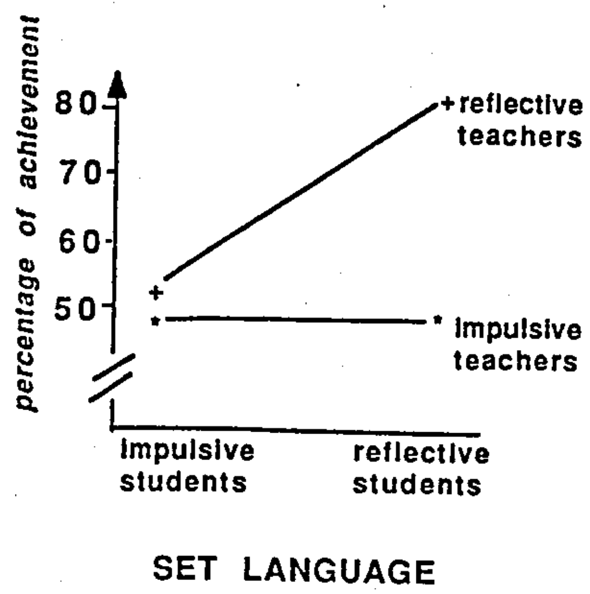


FIGURE 4.5 - SET LANGUAGE

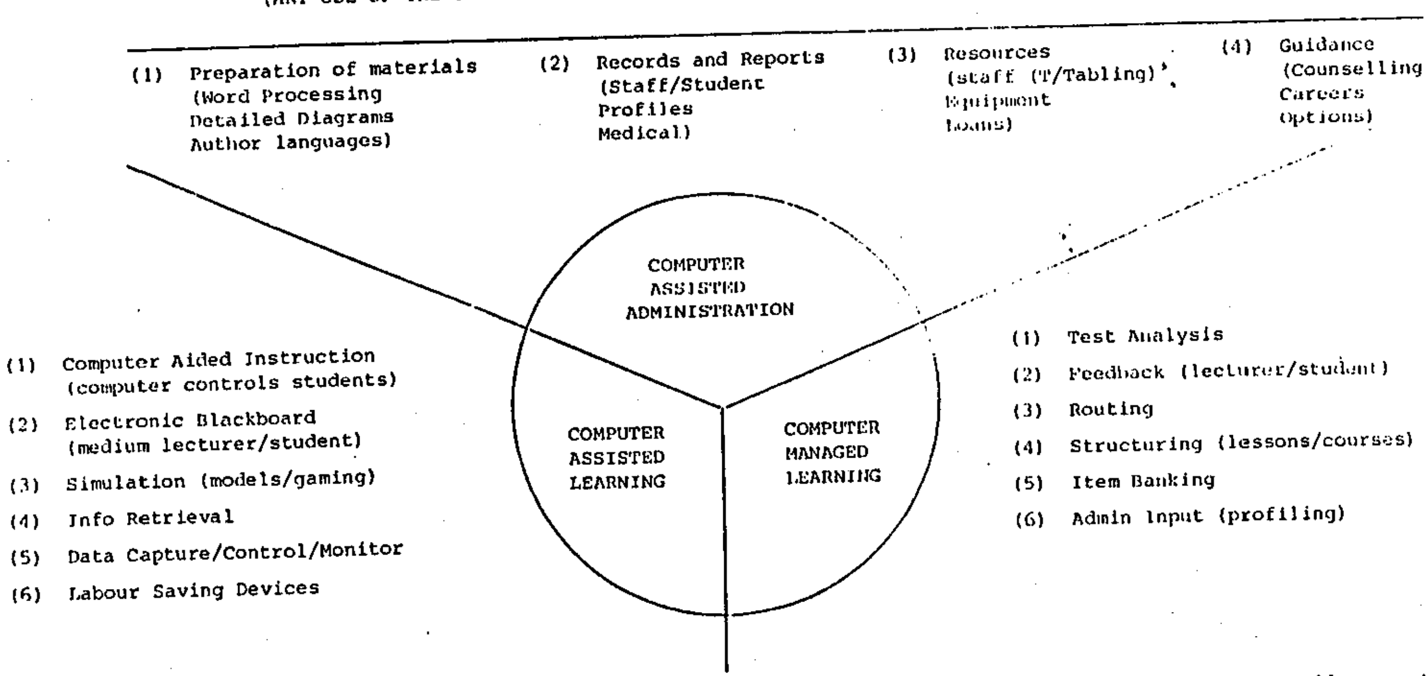
Progressive	Traditional
1 Integrated subject matter	Separate subject matter
2 Teacher as guide to educational experience	Teacher as distributor of knowledge
3 Active pupil role	Passive pupil role
4 Pupils participate in curriculum planning	Pupils have no say in curriculum planning
5 Learning predominantly by discovery techniques	Accent on memory, practice and rote
6 External rewards and punishments not necessary, i.e. intrinsic motivation	External rewards used, e.g. grades, i.e. extrinsic motivation
7 Not too concerned with conventional academic standards	Concerned with academic standards
8 Little testing	Regular testing
9 Accent on cooperative group work	Accent on competition
10 Teaching not confined to classroom base	Teaching confined to classroom base
11 Accent on creative expression	Little emphasis on creative expression
We would add:	
12 Cognitive and affective domains given equal emphasis	Cognitive domain is emphasised; affective is neglected
13 Process is valued	Little attention paid to process

FIGURE 4.6 - COMPARISON OF DIFFERENT TEACHING STRATEGIES

APPENDIX 5

COMPUTER BASED LEARNING

(ANY USE OF THE COMPUTER WHICH DIRECTLY OR INDIRECTLY ENHANCES THE LEARNING)



NOTE: The three domains are devices to clarify functions of particular packages and are by no means universally accepted or exhaustive.

Generally speaking:-

Computer Assisted Learning involves the student INTERACTING with the computer
Computer Managed Learning changes the testing situation into a learning/teaching environment
and Computer Assisted Administration takes from the teacher the onerous admin tasks which at times detract from his teaching but need to be done!

FIGURE 5.1 - COMPUTER BASED LEARNING - DEFINITION OVERVIEW

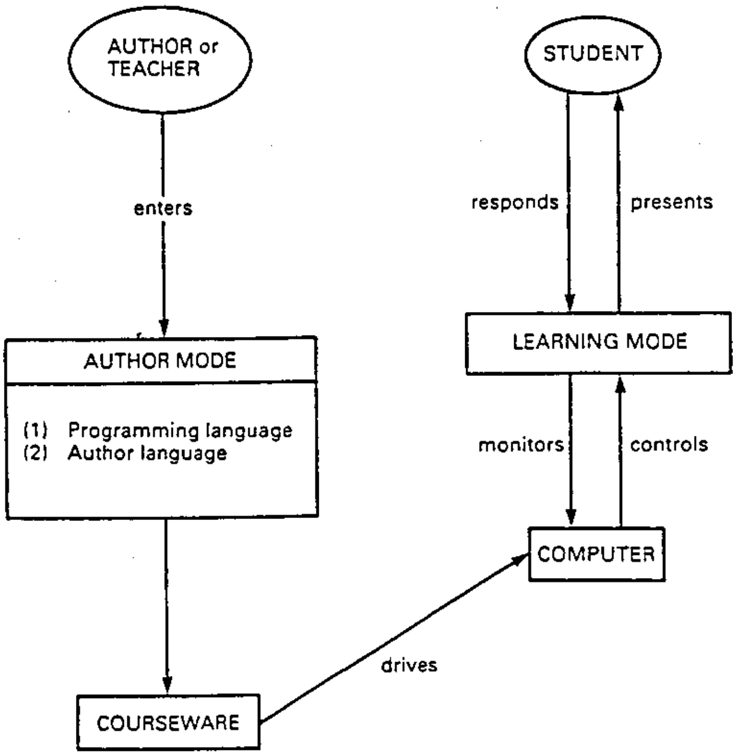


FIGURE 5.2 - MODES OF USING AN INSTRUCTIONAL COMPUTER

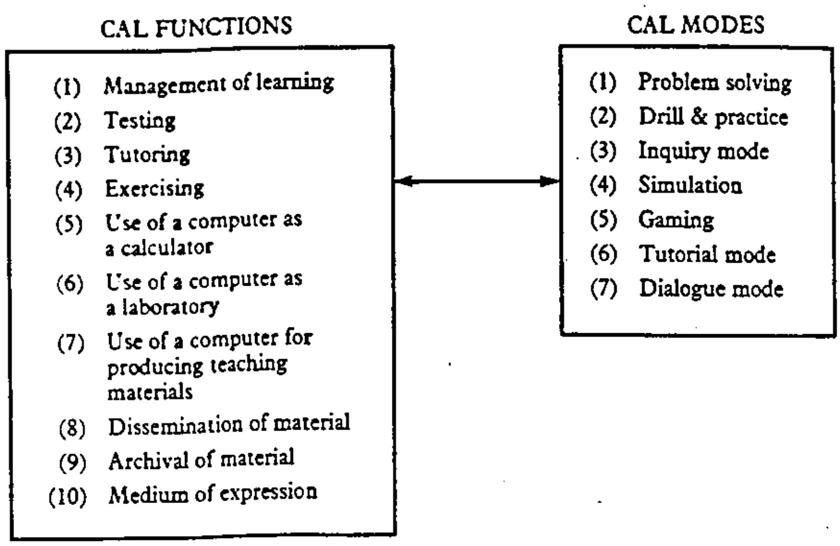


FIGURE 5.3 - THE SCOPE OF CAL - FUNCTIONS AND MODES

1. Demonstration/textbook mode 2. Drill and practice 3. Programmed learning - linear mode 4. Programmed learning - branching mode 5. Educational games	INSTRUCTIONAL
6. Case studies and simulations 7. Problem-solving	REVELATORY
8. Creative activities, e.g. in LOGO	EXPLORATORY (conjectural)
9. Maths. packages (stats/spreadsheets) 10. Word processing 11. Database packages	UTILITY (emancipatory)

FIGURE 5.4 - KEMMIS et al CLASSIFICATION OF CAL MODES

FIGURE 5.5 - WELLINGTON'S FRAMEWORK OF TYPES OF CAL

1. *Instruction* (CAI)	2. *Revelatory* (Simulation)	3. *Conjectural* (Modelling)	4. *Emancipatory* (Labour-saving)
Drill and practice Programmed learning, e.g. Structured Q & A dialogue in a definite sequence Learner is led by computer	*Of real situations:* Trying out an existing model Varying external conditions Discovering the nature of a model, i.e. guided discovery learning *Of imaginary situations:* Games of adventure, logic and skill Educational games	Making and testing a model of reality Testing ideas and hypotheses Drawing conclusions and discovering patterns from a set of data, e.g. historical models	Computer as a labour-saving device, e.g. calculating, drawing graphs, capturing data, statistical analysis, filing data, retrieving information

COMPUTER IN CONTROL ◄———————►	STUDENT IN CONTROL
(Subect-centred)	(Learner-centred)
Content-laden	Content-free

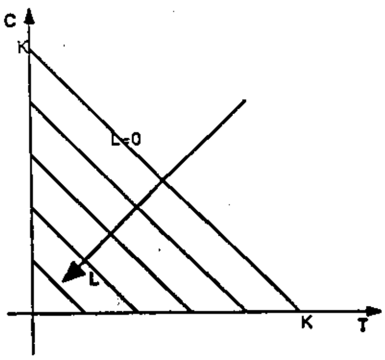


FIGURE 5.6 - ARMSTRONG'S et al MODEL OF COMPUTER, LEARNER,AND TEACHER/LECTURER CONTROL ON CAL

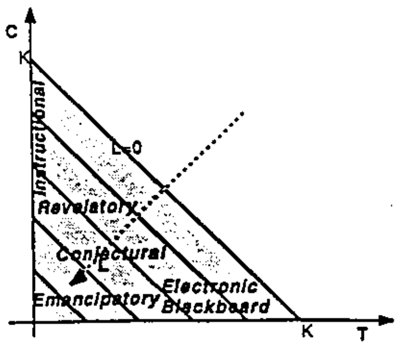


FIGURE 5.7 - EXTENSION OF ARMSRONG'S et al MODEL TO INCORPORATE TYPES OF CAL

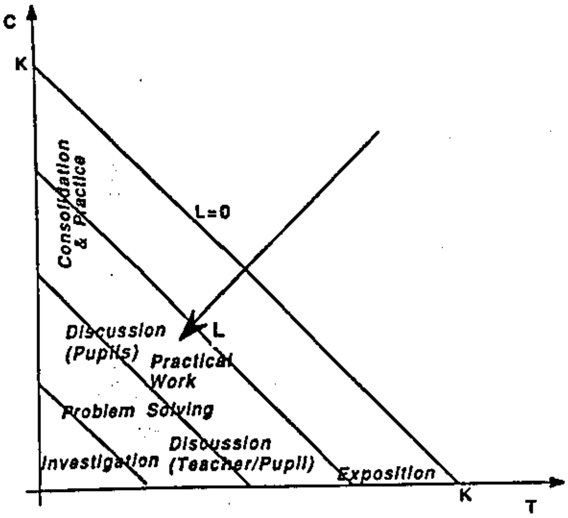


FIGURE 5.8 - ARMSTRONG'S et al MODEL PORTRAYING DIFFERENT TEACHING/LEARNING STRATEGIES

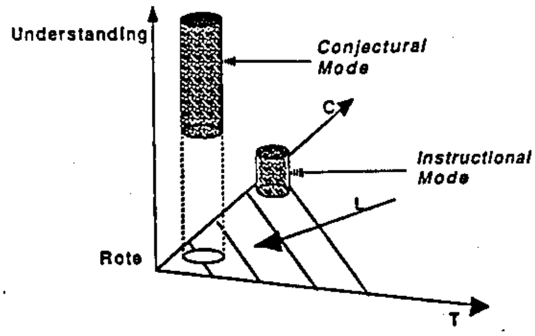


FIGURE 5.9 - ARMSTRONG'S MODEL ILLUSRATING REPRESENTATION OF CAL MODES AND THEIR RELATIONSHIP TO TYPES OF LEARNING

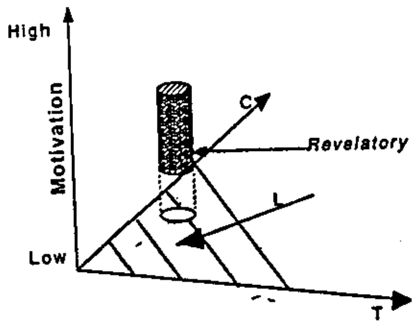


FIGURE 5.10 - ARMSTRONG'S et al MODEL ILLUSTRATING REPRESENTATION OF CAL MODES AND THEIR RELATIONSHIP TO MOTIVATION

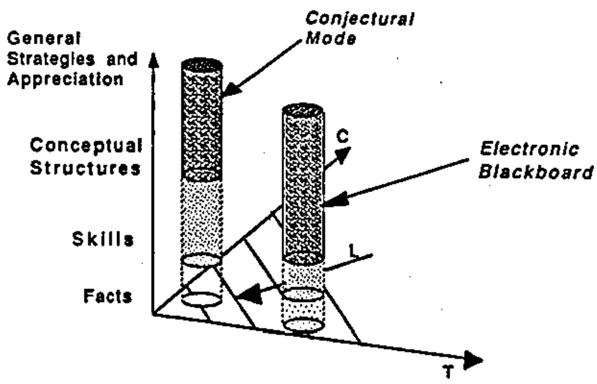


FIGURE 5.11 - ARMSTRONG'S et al MODEL ILLUSTRATING REPRESENTATION OF CAL MODES AND THEIR RELATIONSHIP TO MATHEMATICAL OR TECHNICAL COMPETENCE

Skinner's illustration of how to develop a programmed learning sequence is directly applicable to the design of CAI tutorial modules, as follows:

1. Obtain a clear, detailed objective specification of what it means to know the given subject matter.
2. Write a series of information, question, and answer frames that expose students to the material in graded steps of increasing difficulty and that frequently retest the same facts from many different angles.
3. Require the learner to be active, i.e., require a response for each frame.
4. Provide immediate feedback for each answer (response).
5. Try to arrange the material and questions in such a manner that the correct response is likely to occur and be reinforced (i.e., avoid errors, so that learning is not accompanied by punishing failures).
6. Permit students to proceed at their own pace.
7. Provide ample backup reinforcement (praise, merits) for diligent and effective work.

FIGURE 5.12 - SKINNER'S ILLUSTRATION OF A PROGRAMMED LEARNING SEQUENCE

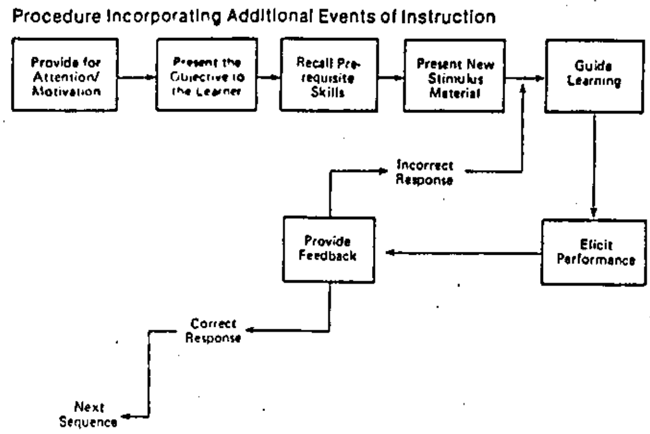


FIGURE 5.13 - GAGNE'S PROCEDURE FOR A TUTORIAL PROGRAM SEQUENCE

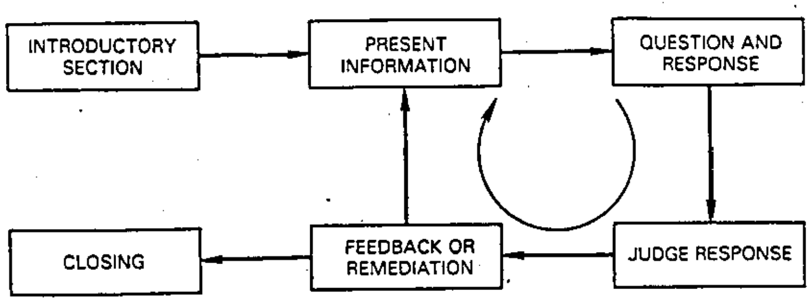


FIGURE 5.14 - STRUCTURE AND SEQUENCE OF A TUTORIAL PROGRAM

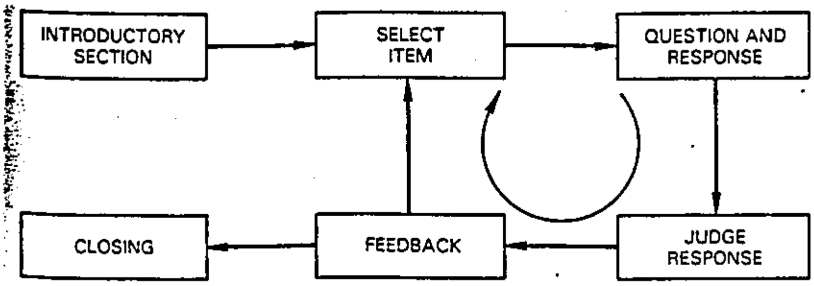


FIGURE 5.15 - STRUCTURE AND SEQUENCE OF A DRILL TYPE PROGRAM

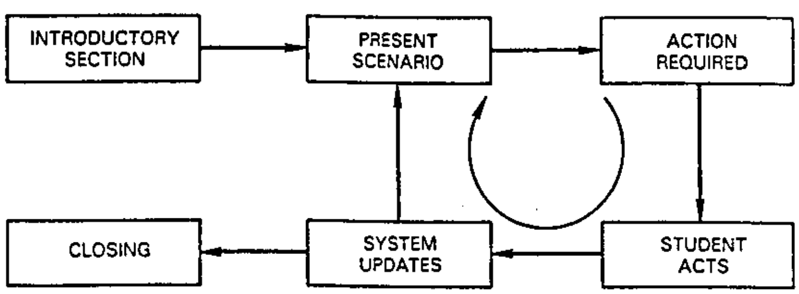


FIGURE 5.16 - STRUCTURE AND SEQUENCE OF A SIMULATION PROGRAM

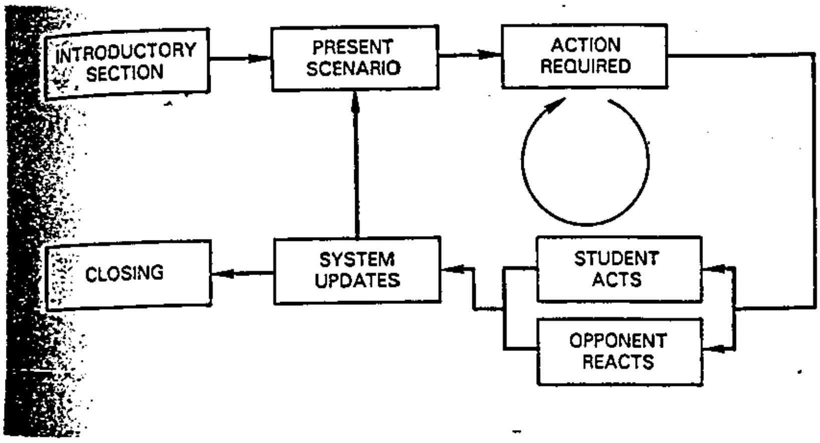


FIGURE 5.17 - GENERAL STRUCTURE AND FLOW OF A GAMES TYPE PROGRAM

BEFORE THE TEST:

Give clear directions.

Give the purpose of the test.

Give the constraints.

Give an opportunity to practice.

Let the student decide when to start the test.

Have safety barriers and nets in place.

DURING THE TEST:

Keep each question on one display.

Keep question format consistent.

Provide easy access to the questions.

Provide capability to change responses.

Provide capability to mark questions for review.

Provide capability to browse through the questions.

Do not penalize format errors.

Provide restart capability.

Let the student know how much time remains.

Have safety barriers and nets in place.

AFTER THE TEST:

Give the results immediately.

Give detailed feedback.

Provide the option for printed results.

State how to leave the testing system.

Provide a way for the student to make comments.

Store all necessary data.

Prevent unauthorized access to results and data.

Have safety barriers and nets in place.

FIGURE 5.18 - FACTORS TO BE CONSIDERED WITH TEST PROGRAMS

STEP 1: DEFINE YOUR PURPOSE

State the general goal, the subject area.

State what part of the subject area you intend to teach in a single lesson.

Produce a chart of the characteristics of intended students.

State a terminal goal for the lesson.

Add the terminal goal to the chart and estimate how much time it will take and how difficult it will be to learn.

STEP 2: COLLECT RESOURCE MATERIALS

Produce a list of resource materials you intend to collect for the subject matter, for instructional development, and for the operation and programming of your computer. Be sure to include knowledgeable people in each category. If you do not know of many resources, go to the resource people for help in generating a list. Collect textbooks, reference books, manuals, films, videotapes, and other materials reflecting the content of the subject and its organization. Be especially watchful for organizational summaries, indices, tables of contents, charts, and graphs. Prepare copies of Appendix A of this text and collect other instructional design texts. Use their bibliographies to locate other useful resources. Collect paper and various graphic arts materials such as graph paper, clear plastic, and a ruler. Have your computer available, and collect manuals and reference guides for it and the programming language you intend to use.

STEP 3: GENERATE IDEAS FOR THE LESSON

Gather three to five people around a small table.

Provide each person with the instructional goals, resource materials, paper, and pens.

Produce as many content ideas as possible without being judgmental.

Stop when few new ideas are being generated.

Give each person a list of instructional methodologies and factors.

Repeat the process to generate ideas about *how* to teach the things listed in the first brainstorming session.

Stop when few new ideas are being generated and a few ideas have been generated corresponding to each idea on the first list.

Save the two lists of ideas for the next step.

STEP 4: ORGANIZE YOUR IDEAS FOR THE LESSON

Eliminate ideas based on student characteristics, subject matter, time, and delivery system limitations.

Analyze the ideas that remain to fill out the details and sequence of the lesson.

Choose a methodology or combination of methodologies.

Make decisions about treatment of all the instructional factors for the methodologies and ideas they will be applied to in the lesson.

Arrange the results of the above four activities in a preliminary lesson sequence.

FIGURE 5.19 - CHARACTERISTICS OF ALLESSI AND TROLLIP'S CAL DESIGN MODEL

SUMMARY OF DISPLAY PRODUCTION

1. Write and revise primary text, which includes information, questions, and feedback.
2. Write and revise secondary text, such as directions, hints, and end-of-lesson messages.
3. Produce storyboards, in which you rewrite all of the materials from the previous two substeps to fit on your computer display.
4. Check the fit of overlapping displays, such as questions and feedback, or information and directions, to make sure that nothing overlaps and that displays are not too crowded.
5. Draw and revise graphics displays and plan other output, which includes pictures, graphs, cartoons, sounds, music, and voice. Graphics should be done, if possible, in the actual size they will appear on the computer display.
6. Check graphics and simultaneous text for fit. Pictures and their descriptions or directions, for instance, should be coordinated to eliminate overlap or crowdedness, as in Substep 4 above.
7. Assemble the storyboards on a bulletin board, blackboard, or large table so they can all be seen at one time.
8. Review the storyboard assembly, looking for errors, checking for completeness, and getting, for the first time, the whole picture of the lesson.
9. Have others review the storyboard assembly. Write down all comments that reviewers make.
10. Make revisions. Fix real problems, but not little details. There will be lots more changing to come in the next two steps.

SUMMARY OF FLOWCHARTING

PREPARATION:

Start the flowcharting process by drawing a simple flowchart without decision points.

Over two or three iterations increase the level of complexity until all details are specified.

Whenever possible put repeated routines in subroutines.

Check that every storyboard is included in the final flowchart.

Ensure that connector numbers are used only once.

Ensure the direction of flow is specified.

DRY-RUNNING:

Plan several paths through the flowchart before dry-running, and note which paths were taken at each decison point.

As you dry-run the chart, keep track of the values of variables.

Check that the flowchart takes you where you expect to go.

Check that all variables have the values you expect.

If there are errors, revise the flowchart.

If you revise the flowchart, dry-run the new version.

FIGURE 5.19 (continued)

BEFORE YOU START:

Choose a programming language, enhancement, or authoring system that meets your instructional needs.

ERROR PREVENTION:

Make a detailed (level three) flowchart of your lesson.
Dry-run the flowchart before programming.
Refer to the flowchart while programming.
Program subroutines first.

PROGRAMMING:

Write the first draft of the program off-line.
Whenever possible use code that you have written before.
Whenever possible amend existing code rather than write new code.
Whenever possible modularize code for efficiency.
Use tracing paper for graphics, placing it over the screen or graphics tablet when creating pictures.
Ensure that the informational detail of each display is in harmony with the instructional objectives.
Document your code thoroughly. Make changes to the documentation whenever you change the code.
Always make your program work before making it efficient.

ERROR DETECTION:

Find and eliminate known bugs first.
Use a systematic approach to error detection.
Plan your debugging with data whose consequences can be easily determined.
Use a set of responses that will give predicted results.
On each display, press all the keys. Only expected ones should have any effect.
Whenever a response is expected of a student, type in unexpected answers, nonsense, and nothing at all. See how the program responds.
Use debugging tools provided for the computer.
Print some identifying numbers on displays to facilitate reference.
Eliminate one bug at a time.
Save existing code until you are certain you do not need it.
Incorporate, if possible, some mechanism whereby the student can make on-line comments.

FIGURE 5.19 (continued)

SUMMARY OF LESSON EVALUATION AND REVIEW

QUALITY REVIEW:

Use the checklist.
Check the language and grammar.
Check the surface features.
Check questions and menus.
Check all invisible functions.
Check the subject matter content.
Check the off-line material.
Revise the lesson.
Apply the same quality-review procedure to all revisions.

PILOT TESTING:

Enlist about three helpers.
Explain pilot-testing procedures.
Find out how much they know about the subject matter.
Observe them go through the lesson.
Interview them afterwards.
Revise the lesson.
Pilot-test all revised lessons.

VALIDATION:

Use the lesson in the setting for which it was designed.
Use the lesson with students for which it was designed.
Evaluate how the students perform in the setting for which you are preparing them.
Obtain as much performance data as you can from different sources.
Obtain data on student achievement attributable to the lesson.
Obtain data on student attitudes toward the lesson.

FIGURE 5.19 (continued)

ASSESSMENT OF SOFTWARE

TITLE	
SOURCE/COST	
EQUIPMENT	
AGE GROUP	
LEVEL	
SUBJECT AREA	
OBJECTIVES	
PRE-KNOWLEDGE	
DOCUMENTATION (TECHNICAL)	
DOCUMENTATION (EDUCATIONAL)	
PRESENTATION- TEXT	
PRESENTATION-GRAPHICS	
PRESENTATION-SOUND	
ROBUSTNESS	
FLEXIBILITY/FRIENDLINESS	
ACHIEVEMENT OF AIMS	
SPECIFIC CRITERIA	
CONCLUSION	

FIGURE 5.20 - EVALUATION QUESTIONNAIRE 1

COURSEWARE REVIEW CHECKLIST

SECTION I: COURSEWARE OBJECTIVE(S)—NEEDS TO BE MET

SECTION II: DEMOGRAPHICS

DATE: ____________________ REVIEWER: ____________________

PRODUCT: ____

SECTION III: SCREENING CRITERIA

1. Is the courseware applicable to the objectives?	Y	N
2. Is the required microcomputer available?	Y	N
3. Are the computer language and operating system available?	Y	N
4. Is the cost within budgetary limits?	Y	N
5. Are the required peripherals available?	Y	N
6. Is the instructional design appropriate?	Y	N
********RECOMMENDED FOR REVIEW?	Y	N

SECTION IV: INSTRUCTOR-RELATED ITEMS

DATE: ____________________ INSTRUCTOR: ____________________

	Poor			Good
A. Administrative Issues				
1. Backup availability and cost	1	2	3	4
2. Defect guarantees and quantity discounts	1	2	3	4
3. Learning environment	1	2	3	4
4. Documentation	1	2	3	4
B. Content Issues				
1. Instructor-controlled parameters	1	2	3	4
2. Accuracy	1	2	3	4
3. Environment	1	2	3	4
4. Pedagogy	1	2	3	4
5. Answer judging	1	2	3	4
6. Branching	1	2	3	4
7. Learning theory	1	2	3	4
8. Time allowances	1	2	3	4
9. Progress reporting	1	2	3	4
10. Professionalism	1	2	3	4
C. Technical Issues				
1. User friendliness	1	2	3	4
2. Error trapping	1	2	3	4
3. Color dependency	1	2	3	4
4. Speed of execution	1	2	3	4
5. Appearance	1	2	3	4

FIGURE 5.21 - EVALUATION QUESTIONNAIRE 2

SECTION V: STUDENT-ORIENTED REVIEW

	Poor			Good
1. Results	1	2	3	4
2. Student Control	1	2	3	4
3. Freedom from Technology	1	2	3	4
4. Motor Skills	1	2	3	4
5. Motivational Value	1	2	3	4

SECTION VI: OVERALL RATING AND COMMENTS

	Poor			Good
*****OVERALL RATING (Note: We recommend only courseware rated 3 or higher be considered for acquisition.)	1	2	3	4

Comments: (Attach additional pages if extra space is needed.)

SECTION VII: POSTIMPLEMENTATION COMMENTS (Attach additional pages if extra space is needed.)

FIGURE 5.21 (continued)

FIGURE 5.22 - EVALUATION QUESTIONNAIRE 3

Complete this sheet by awarding a score for each aspect which describes how well you consider it has been achieved by the package, place a √ in the appropriate column. 5 is highest, 1 is lowest, N/A is not applicable. Use the blank space to record your additional comments.

Name of package ______________________

Name of program ______________________

You may wish to photocopy this sheet.

		5	4	3	2	1	N/A	*Additional comments*
1	**Educational documentation**							
1a	Statement of aims and objectives	☐	☐	☐	☐	☐	☐	
1b	Information about the content and background	☐	☐	☐	☐	☐	☐	
1c	Statement of intended type of use and audience	☐	☐	☐	☐	☐	☐	
1d	Suggestions of ways to use the program	☐	☐	☐	☐	☐	☐	
1e	Pupil activities or worksheets	☐	☐	☐	☐	☐	☐	
1f	Instructions for running the program	☐	☐	☐	☐	☐	☐	
1g	Presentation of a typical run	☐	☐	☐	☐	☐	☐	
1h	*General impressions*	☐	☐	☐	☐	☐	☐	
2	**Achievement of stated aims** ***(as far as you can tell without actually using the program with a class)***							
2a	Aims/objectives	☐	☐	☐	☐	☐	☐	
2b	*General impressions*	☐	☐	☐	☐	☐	☐	
3	**Appropriateness of the micro and program**							
3a	For teaching this topic	☐	☐	☐	☐	☐	☐	
3b	For the suggested audience and type of use (e.g. group whole class, etc.)	☐	☐	☐	☐	☐	☐	
3c	*General impressions*	☐	☐	☐	☐	☐	☐	
4	**Screen presentation**							
4a	Use of graphics	☐	☐	☐	☐	☐	☐	
4b	Use of colour and animation	☐	☐	☐	☐	☐	☐	
4c	*General impressions*	☐	☐	☐	☐	☐	☐	

		5	4	3	2	1	N/A	*Additional comments*
5	**Friendliness and flexibility of the program**							
5a	Helpful messages to correct user errors	☐	☐	☐	☐	☐	☐	
5b	Help to pupils in understanding the program	☐	☐	☐	☐	☐	☐	
5c	Versatility so that the user can control what the program does	☐	☐	☐	☐	☐	☐	
5d	Feedback to pupil	☐	☐	☐	☐	☐	☐	
5e	Program adapts to pupils' performance	☐	☐	☐	☐	☐	☐	
5f	Record of pupils' performance kept by program	☐	☐	☐	☐	☐	☐	
5g	Program model accessible to pupil	☐	☐	☐	☐	☐	☐	
5h	Suggestions or help for teacher to modify the program	☐	☐	☐	☐	☐	☐	
5i	*General impressions*	☐	☐	☐	☐	☐	☐	
6	**Technical documentation**							
6a	Information about machine requirements	☐	☐	☐	☐	☐	☐	
6b	Information about the model used	☐	☐	☐	☐	☐	☐	
6c	Information about the program structure	☐	☐	☐	☐	☐	☐	
6d	Listing and readability of the program code	☐	☐	☐	☐	☐	☐	
6e	Portability, i.e. ability to transfer program to a different computer	☐	☐	☐	☐	☐	☐	
6f	*General impressions*	☐	☐	☐	☐	☐	☐	
Summary of overall impressions								
	Give an overall score for each of the categories 1–6							
1.	Educational documentation	☐	☐	☐	☐	☐	☐	
2	Achievement of stated aims	☐	☐	☐	☐	☐	☐	
3	Appropriateness of the media and the program	☐	☐	☐	☐	☐	☐	
4	Screen presentation	☐	☐	☐	☐	☐	☐	
5	Friendliness and flexibility of the program	☐	☐	☐	☐	☐	☐	
6	Technical documentation	☐	☐	☐	☐	☐	☐	

FIGURE 5.22 - (CONTINUED)

APPENDICES 5.1

LIST OF COURSEWARE DISTRIBUTORS AND TYPICAL EXAMPLES OF COURSEWARE

LIST OF SOFTWARE SUPPLIERS FOR BTEC LEVEL COURSES.

BYTRONIC ASSOCIATES

FARNELL ELECTRONIC COMPONENTS

GARLAND COMPUTER SOFTWARE

MEGACYCL SOFTWARE

PLYMOUTH OPEN LEARNING SYSTEMS UNIT

MICA SOFTWARE

<u>NOTE :-</u> ADDRESSES AND FURTHER INFORMATION SUPPLIED ON REQUEST.

6

Acorn Computer Software — continued

PCB Design [illegible] MICRONOVA

Two programs for designing single and double sided printed circuit boards. The draughting program covers the PCB design, using a four colour system capable of displaying both sides of the PCB simultaneously on a video monitor. The maximum actual PCB size is in excess of 2ft by 2ft. Various pad sizes up to 1" diameter can be set, and 0.1" pads laid down with a single key stroke. Automatic bussing allows quick connection of power supply rails and/or data and address lines.

The printing program runs on Epson printers such as the LX-Series and produces accurate printouts at a scale of 2:1 or 4:1, suitable for direct photo reduction. An actual size (1:1) printout can be made for reference purposes. Any printed artwork may be mirror imaged and a solder resist mask produced for each side of the board if required.

Both the draughting and printing programmes are supplied on one 5¼" single sided floppy disk. Several enhancements have been made to the software, such as an automatic saving of draughted material on return to the control mode, and compatibility with the FX/LX Series printers. Back-up copies may be taken from the master disk for which serial numbered labels are supplied.

176-073 is an upgrade disk which allows users of the original software to operate it on the BBC 'Master'.

Note: The 6502 2nd processor or a 32K expansion card is required to run the above programs.

	Order Code	Price Each
PCB drafting/printing disk for BBC Micro 80 trk	193-152	£99.00
PCB drafting/printing disk for BBC Micro 40 trk	193-153	£99.00
40/80 trk upgrade disk for original version	176-073	£18.50

Educational Software For BBC Micro 'B' and Master

DIGITAL-LOGIC—Disk
Covers basics of digital logic gates. The booklet explains truth tables, Boolean equations and the addition of binary numbers. All the relevant theory required for the program is covered and questions are set to review the users understanding of the program material. The program is in 8 sections: Sections 1 and 2 cover AND, NAND, OR, NOR and EXOR logic gates, Sections 3 and 4 cover the half and full adder arrangements, Sections 5, 6 and 7 cover the RS flip-flop, the Bistable latch and J/K flip-flop respectively, Section 8 covers the Binary Ripple counter.

DIGITAL DEVICES—Disk
Intended as a follow-up to the Digital-Logic package described above, the Digital Devices package examines the functional operation and application of a range of digital devices. The devices introduced in this package are a 4-bit Binary/BCD up/down counter, a seven-segment display and decoder, an 8-bit shift register, a ROM and a RAM.
As with the other packages in this series, full use is made of interactive graphics, the user is tested on many points that are raised during the training session. The booklet supplied gives background information on the devices, also introducing applications, and covers all the theory required.

AMPLIFICATION—Disk
Treats amplification as a function performed on electronic signals. Explained in the booklet is the role of input and output transducers, the significance of correct amplifier grounding, input/output transfer functions, output limits, equivalent circuits and the importance of correct input and output matching. The program is in 6 sections: Section 1 explains the single ended amplifier, investigating the interaction between gain, power supply values and input signal magnitude, Section 2 covers the same for differential input amplifiers, Section 3 provides questions on 1 and 2, Section 4 demonstrates the relationship between input and output waveforms, illustrating clipping. Sections 5 and 6 cover the use of Thevenin equivalent circuits as applied to amplifiers.

OPERATIONAL AMPLIFIER—Disk
Explains the functions of an operational amplifier and examines its behaviour in several different negative feedback configurations. The booklet explains the background theory of negative feedback and introduces the equations used in the program. The program is divided into 3 sections: Section 1 offers three models of the basic feedback circuit, namely the inverter, the follower and the inverting adder, Section 2 presents a number of questions which require the use of the equations presented in the booklet, based on the ideal op-amp, Section 3 covers problems associated with 'real' op-amps and the effect of finite loop gain.

OPERATIONAL AMPLIFIER APPLICATIONS—Disk
This package is designed to give an understanding of the main factors influencing the accuracy of practical operational amplifier circuits, and to act as an engineer's design aid in error evaluation. The package assumes the user has a knowledge of the function of the amplification process, of frequency response terminology and of basic negative feedback concepts.

FREQUENCY RESPONSE—Disk
Explains amplitude and phase relationships which exist between the input and output of an amplifier. All the terms and equations used in the programmes are explained in the booklet. The program is split into 3 sections: Section 1 demonstrates the frequency response for first order high and low pass filters displaying the amplitude and phase relationship in a table and showing attenuation in dB, Section 2 shows the frequency response obtained when two first order systems are connected in cascade and Section 3 displays the open and closed loop frequency response obtained with operational amplifier feedback circuits. Various circuit parameters may be altered as required.

DC CURRENT ELECTRICITY—Disk
Introduces the user to direct current circuits and introduces Ohms Law. All required theory is covered in the booklet supplied together with the equations used. The programme is divided into 6 sections: Section 1 covers amps, volts and ohms and their relationships, Section 2 contains tests on ohms law, Section 3 introduces the concepts of EMF and internal resistance, Section 4 provides a set of tests on series and parallel connection of resistors and Sections 5 and 6 show the use of galvanometer shunts and multipliers, ammeters and voltmeters.

DATA CONVERSION—Disk
Introduces the techniques used in data converters. Split into three programs, Program 1 covers the functional binary codes used by converters such as natural binary, BCD, offset binary and two's complement, as well as explaining conversion from decimal to binary and vice-versa. Program 2 presents an interactive model illustrating D to A conversion and Program 3 presents A to D conversion. All the codes introduced in Program 1 can be used in Programs 2 and 3.

D-to-A CONVERSION—Disk
Supplies more specific information relating to the Digital-to-Analogue converter. Basic information covered in the Data Conversion package is expanded to cover the use of R-2R networks and how they generate binary current increments. Interactive models cover bit switches and output operational amplifiers, other models cover scale trimming and offset binary operation. The final model explains the role of reference voltage and the scale setting resistor. It is recommended that the user is familiar with the Data Conversion and Digital Devices software before using this program.

A-to-D CONVERSION—Disk
This program covers the Analogue-to-Digital conversion process, introducing four types of A-to-D converter, the tracking converter, a successive approximation converter, a dual slope converter and a parallel converter. The main parameters affecting the A-to-D converter under discussion can be altered and waveforms generated by the conversion are displayed.
From this program a clear understanding of the different conversion techniques can be gained. It is recommended that the user is familiar with both the Digital Devices and the Data Conversion disks before using this program.

AC BASICS—Disk
This package is intended to examine the relationships between voltage and current for capacitors and inductors, and also the terms which are used in describing the characteristics of alternating current.

AC CIRCUITS—Disk
This programme is an extension of AC BASICS. It covers phasor diagrams and mathematical manipulation. The interaction of inductive and capacitive elements in serial and parallel configurations is dealt with, together with resonant circuits.

MEASUREMENT—Disk
This package covers measurement of both a mechanical and electronic nature; vernier calipers, micrometers, multimeters and oscilloscopes are dealt with.

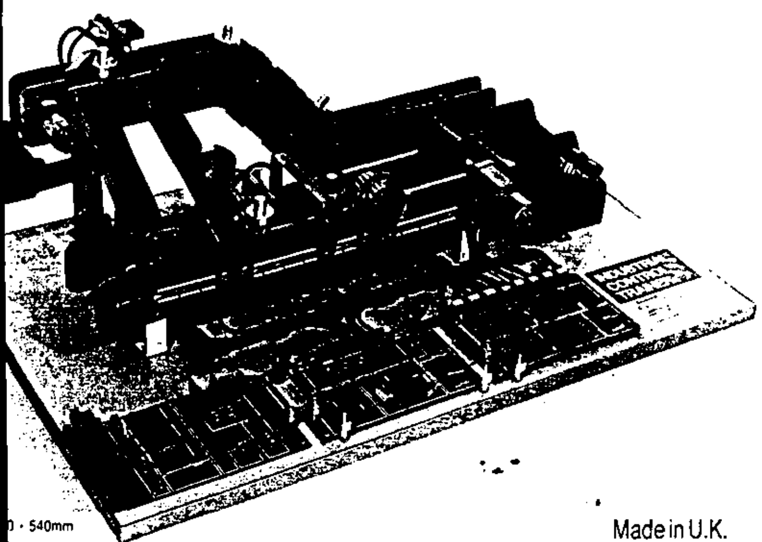
Note: All software supplied on a 5¼" 40 track disk.

	Order Code	Price Each
Digital-Logic	193-000	£13.95
Digital Devices	193-001	£13.95
Amplification	193-010	£13.95
Operational Amplifier	193-020	£16.00
Operational Amplifier Applications	193-021	£19.50
Frequency Response	193-030	£13.95
DC Current Electricity	193-040	£11.95
Data Conversion	193-135	£13.95
D-to-A Conversion	193-136	£13.95
A-to-D Conversion	193-137	£13.95
AC Basics	193-041	£16.00
AC Circuits	193-042	£16.00
Measurement	193-049	£12.00

BSI REGISTERED STOCKIST

REG. NO. RS118

NDUSTRIAL CONTROL TRAINER



D · 540mm

Made in U.K.

Realistic Application for Teaching PLC & Microcomputer Control.

Unique Universal Interface Allows Unit to be Easily Linked to ANY PLC or Microcomputer with I/O.

Component Sorting & Assembly.

Includes Inductive, Capacitive & Opto-Electronic Sensors.

2 × D.C. Motors & 3 Solenoid Actuators.

Component Test & Accept/Reject.

Built-In Switched Fault Facility.

Supplied with User Manual & Student Labworks

ndustrial Control Trainer (ICT1) unit has been specifically designed aching PLC and Microcomputer control applications. The unit is ured as a typical industrial process in which two different components orted, assembled and then tested for correct assembly.
CT1 provides a realistic system for studying on-off control. analogue l, sensor feedback, dc motor conveyor control, dispensing and nbly methods.
ue, fully labelled interface allows the unit to be connected to virtually C or microcomputer that has a minimum of 6 digital outputs and 6 inputs. A switched fault facility enables various common faults to plied to the system. Using these the student can test the integrity r control programs or identify faults using standard test equipment. al different industrial sensors test each assembled unit as it passes the system. Components which fail a test can be rejected for recycling. nt exercises can be graded in complexity from simple open-loop. component programs through to controlling the complete assembly- quence. Each unit is supplied with a comprehensive manual which es student programming exercises in ladder logic and BASIC. A supply unit providing 12V @ 2 Amps is required. FACT SHEET T1

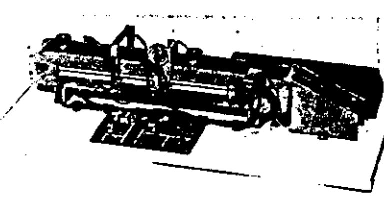
DERING INFORMATION

CRIPTION	CODE	PRICE
strial Control Trainer	ICT1	£1950
Interface (see P7)	MPBBC1	£98
Interface to ICT Connector	MPCT2	£15
Interactive Program	ICT3BB	£35
Internal Interface (see P6)	MPIBM1	£85
Interface to ICT Connector	ICT6	£25
External Interface*	MPIBM2	£95
External Interface Connector*	MPCT2	£15
Interactive Program	ICT3PC	£35
e Conveyor Module	ICT4	£595
Internal to ICT4 Connector	ICT7	£25
to ICT4 Connector	ICT8	£20
or Expansion Module	ICT4A	£198
OM Program for Mitsubishi	ICT3PLC	£65
r Supply Unit 12V @ 2 Amp (see P5)	MPPS2	£150

nal: See P6 for details

tsubishi series of PLCs represent excellent value for money and eally suited for teaching ladder programming techniques to s., A wide range of Base Units, I O Extension Units and mming devices ensure that virtually every need can be catered for, t a remarkably low price!
shi PLCs have successfully established themselves in both the ional and Industrial marketplace where their ease of programming able design are well recognised.
for advice or a comprehensive price list. FACT SHEET T4

) PLC Base Unit	F1-20MR-ES	£222
et Sized Programmer	F1-20P-E	£132



Photograph shows Single Conveyor fitted with Sensor Expansion Module.

Made in U.K. 770 × 180 × 390mm

This low cost conveyor (ICT4) features a 12V DC Motor. linear acting solenoid plus opto-through beam and opto-reflective sensors. The unit may be linked to a microcomputer or virtually any PLC. Students can write programs to detect, identify and accept reject different components. An optional Sensor Expansion Module (ICT4A) containing inductive and capacitive transducers is available for more advanced programming tasks. FACT SHEET T3

PLC TRAINING PACKAGE

The PLC PACK 1 provides everything needed for setting up and teaching PLC control. The package contains a Bytronic Industrial Control Trainer, Mitsubishi F1 20 I.O Programmable Logic Controller with Programming Keypad and a ready programmed EPROM. The PLC is mounted on a pre-wired base enabling very easy and rapid connection to the ICT. Comprehensive courseware is also provided in the form of a Student Manual plus a separate Lecturers Manual. These manuals assume no prior knowledge of PLC control and feature several programming exercises.
The PLC-PACK 1 offers all the hardware, software and courseware you require combined into a single training package and all at a truly remarkable low price. For more details send for our PLC-PACK 1 fact sheet. FACT SHEET T2

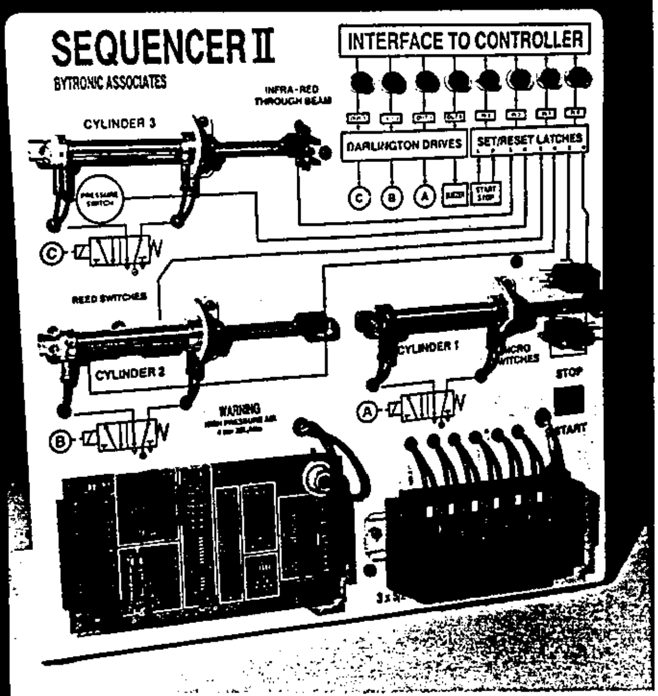
PLC-PACK 1 PLC Training Package	PLC-PK1	£2299

PLC IN-HOUSE TRAINING COURSE

Bytronic can provide in-house training courses on PLC control for those departments who are contemplating teaching this subject or which have recognised a need for staff training in this area. The 2 day, highly intensive course has been especially developed with the professional lecturer trainer in mind. The popular Misubishi F1 PLC is used to control various Bytronic Application Units including the Industrial Control Trainer. The emphasis is geared towards hands-on experience and after completing the course delegates will understand the architecture of a PLC. how it operates and how it can be programmed in ladder logic. For further details send for our PLC TRAINING COURSE data sheet. FACT SHEET T5

2 Day PLC Training Course for up to 4 delegates	PLC-CR1	£800
* Phone for charges for 5+ delegates		

SEQUENCER II



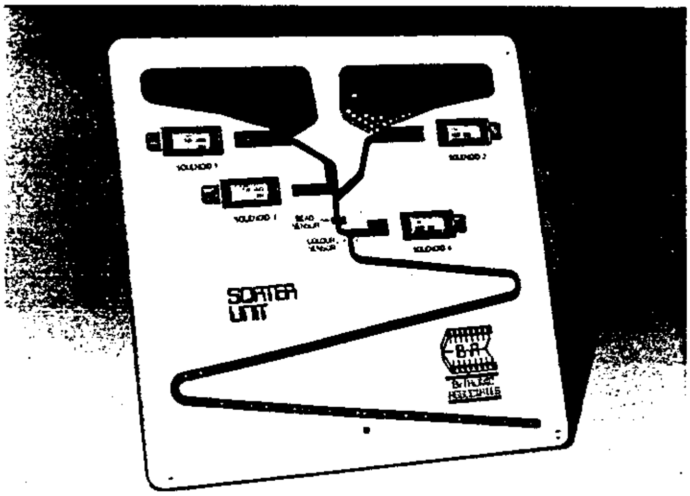
50 x 150mm Made in U.K.

Sequencer II is a new, enhanced version of the highly successful uencer Unit.
unit may be easily interfaced to a BBC Micro or IBM PC (+ Clones) or tually any Programmable Logic Controller. This allows the development pen or closed loop control programs in either a high or low level puter language or in PLC Ladder Logic. Any combination of three ns may be activated. Feedback is provided by various industrial-type ors, namely microswitches, magnetic reed switches, opto-through n and a pressure switch sensor. An array of 3 solenoids, pneumatic valves and warning buzzer comprise the 4 output devices. The Hi/Lo s of all input and output lines are displayed on a row of lamps esenting the 8 bit data port. These data lines are connected to the us sensors and actuators via a system mimic so that students can y see how each I/O line is used.
ly labelled PCB mounted on the front of the unit features full opto-tion and test points. Four built-in switched faults allow students to y test the integrity of their control program and fault find electronics. Sequencer II can be linked directly to a BBC Micro or PLC. An I/O is required if connecting the unit to an IBM PC Micro (see P6). onal software includes a unique Computer Based Learning program eaching microcomputer control plus an Interactive Program for quick p and demonstration of the unit.
ower Supply providing 12V @ 1 Amp and Air Supply capable of ding 4 bar at 20 litre/min are required. **FACT SHEET A1**

DERING INFORMATION	SEQUENCER II		SORTER	
SCRIPTION	CODE	PRICE	CODE	PRICE
QUENCER II	SQ2	£698	–	–
Compressor for SQ2	SQ2A	£195	–	–
RTER UNIT	–	–	MPSR1	£275
wer Supply Unit (see P5)	MPPS2	£150	MPPS2	£150
C Interactive Program	SQ2BB	£35	MPSR2BB	£35
C Connecting Cable	MPCT3	£15	MPSR3	£20
I Interactive Program	SQ2PC	£35	MPSR2PC	£35
I Internal Interface (see P6)	MPIBM1	£85	MPIBM1	£85
I Internal Connector	SQ4	£25	MPSR4	£25
I External Interface*	MPIBM2	£95	MPIBM2	£95
I External Connector*	MPCT1	£15	MPCT1	£15
versal PLC Interface (see P7)	–	–	MPPL1	£149
C Interface Connector	–	–	MPCT3	£15

ptional: See P6 for details

SORTER UNIT



295 x 295 x 40mm Made in U.K.

This versatile unit simulates a counting and sorting system of the kind commonly found in industry. It may be controlled by any microcomputer or PLC which can send 6 digital output and accept 2 digital input TTL signals. In Count Mode two differently coloured beads are dispensed in a particular order by controlling the action of two of the four solenoids. In Sort Mode the unit is simply turned upside down and the beads sorted back into their respective hoppers. Opto-electronic sensors provide feedback to the controller enabling closed loop control programs to be written. A built-in alarm can be activated if an error occurs, eg. hopper empty or bead stuck. Optional software includes a unique Computer Based Learning program for teaching microcomputer control plus an Interactive Program for quick set-up and demonstration of the unit.
The Sorter Unit is supplied with comprehensive documentation and requires a 14V @ 1 Amp Power Supply. **FACT SHEET A2**

COMPUTER BASED LEARNING

These two unique programs use the Sequencer II or Sorter Units as target systems for introducing students to the exciting world of control programming. Each CBL package is supplied with a Student Workbook and Program Disc which is divided into several interactive tutorials and is equivalent to approximately 12 hours of lecture time. On completion of the course students will understand how a microcomputer can control external devices and be able to write closed loop control programs. **FACT SHEET C1**

Tutorials include:

- Introduction to Microcomputers – Fundamental Terminology.
- Binary Codes, Decimal to Binary Conversion.
- The I/O Port, its Function and Use.
- The Data Direction Register and its Initialisation.
- The Need for Signal Amplification.
- Outputting Commands for Solenoid Movement.
- The Importance of Delays to Allow Time for Electro-Mechanical Devices to Respond.
- Introduction to Writing Open Loop Programs.
- Introduction to the Use of Sensors.
- Inputting Signals from the Outside World, i.e. Feedback.
- Masking Out Unwanted Signals – The 'AND' Instruction.
- Introduction to Writing Closed Loop Control Programs.
- Student Assignment.

ORDERING INFORMATION		SEQUENCER II CODE	PRICE	SORTER CODE	PRICE
Single Licence	BBC	CBL1BB	£99	CBL2BB	£99
	IBM PC	CBL1PC	£150	CBL2PC	£150
Multi-User Licences	BBC	CBL1B8	£250	CBL2B8	£250
(Up to 8 computers)	IBM PC	CBL1P8	£350	CBL2P8	£350
Additional Licences	BBC	CBL1BX	£35	CBL2BX	£35
(Per computer)	IBM PC	CBL1PX	£45	CBL2PX	£45

POLSU
COLLEGE OF FURTHER EDUCATION,
KINGS ROAD, DEVONPORT, PLYMOUTH PL1 5QG.
TEL (0752) 551947 OR 264762 (24 HOURS)

SEPTEMBER 1988 (VALID TO APRIL 1989)

PLEASE NOTE: POLSU's Electronics and Microelectronics packages are designed to meet BTEC's requirements for various single units. BTEC is currently changing over to N level units. If you are embarking on the BTEC N level scheme, you should only purchase packages with N in their titles. If you are finishing off courses on the BTEC scheme that is being phased out, you should purchase packages without N in their titles.

RODUCT	ORDER CODE	NETT PRICE £	VAT	PRICE PLUS VAT £
OMPLETE PACKAGES				
ontain hardware/software and learning guides as appropriate)				
ICROELECTRONIC SYSTEMS I	MES 1A	289.00	15%	332.35
ICROELECTRONIC SYSTEMS II	MES 2A	391.00	15%	449.65
ICROELECTRONIC SYSTEMS NII	MN2	406.00	15%	466.90
ICROELECTRONIC SYSTEMS III	MES 3A	423.00	15%	486.45
ICROELECTRONICS FOR INDUSTRY (Covers all material in MES 1A, 2A and 3A)	MES 4A	470.00	15%	540.50
IGNATURE ANALYSIS	SAKA	400.00	15%	460.00
RACTICAL ELECTRONICS	PE	52.00	15%	59.80
LECTRONICS NII	EN2	310.00	15%	356.50
LECTRONICS III	E3	114.00	15%	131.10
BC COMPUTER APPLICATIONS	BBC 1A	150.00	15%	172.50
ART PACKAGES				
ICROELECTRONICS MES 1A to MES 2A update	MES 2B	160.00	15%	184.00
ICROELECTRONICS MES 1A to MN2 update	MN2U1	163.00	15%	187.45
ICROELECTRONICS MES 2A to MN2 update	MN2U2	53.00	15%	60.95
ICROELECTRONICS MES 2A to MES 3A update	MES 3B	80.00	15%	92.00
ICROELECTRONICS MES 1A to MES 3A update	MES 3C	230.00	15%	264.50
BC COMPUTER APPLICATIONS (Cable and guides)	BBC 1B	30.00	15%	34.50
EARNING GUIDES				
CROELECTRONIC SYSTEMS I GUIDES* (Complete set of three guides and textbook)	BM1	16.50	0	16.50
CROELECTRONIC SYSTEMS II GUIDES* (Complete set of three guides and textbook)	BM2	22.95	0	22.95
CROELECTRONIC SYSTEMS NII GUIDES (Complete set of three guides)	BMN2	35.00	0	35.00
CROELECTRONIC SYSTEMS III GUIDES* (Complete set of three guides and textbook)	BM3	24.95	0	24.95

PRODUCT	ORDER CODE	NETT PRICE £	VAT	PRICE PLUS VAT £
LEARNING GUIDES (Continued)				
IGNATURE ANALYSIS (Complete set of four workbooks)	BSAK	40.00	0	40.00
LECTRONICS NII GUIDES (Complete set of four guides)	BEN2	45.00	0	45.00
LECTRONICS III GUIDES (Complete set of thirteen guides)	BE3	45.00	0	45.00
ITRODUCTION TO MICROPROCESSOR SYSTEMS (Complete set of two guides)	BMS	20.00	0	20.00
OFTWARE DIAGNOSTICS (Workbook)	BSD	10.00	0	10.00
I-CIRCUIT EMULATION (Set of two guides)	BIC	15.00	0	15.00
OGIC ANALYSIS (Workbook)	BLA	10.00	0	10.00
IDEOS				
IGNATURE ANALYSIS	VSA	75.00	15%	86.25
I-CIRCUIT EMULATION	VIC	50.00	15%	57.50
OGIC ANALYSIS	VLA	75.00	15%	86.25

ALL ITEMS – TUITION, POST AND PACKING EXTRA

DELIVERY – One to twelve weeks, depending on order quantity.

CHEQUES – All cheques should be made payable to Devon County Council.

Discount on quantities of complete and part packages:-
1 - 4 = Nil% 5 - 9 = 5% 10 - 19 = 10% 20+ = 20%
Discount does not apply to learning guides.

* Contains textbook subject to publisher's price review in January.

	Order Code	Price Each Per Quantity 1+	5+
Board inc. manual	RTI-820	£561.00	£532.95
Spare manual for RTI-820	AC1905	£21.00	——
Screw termination unit	AC1585-1	£102.00	£96.90
High level input panel inc. manual	STB-HL02	£307.00	£291.65
Spare manual for STB-HL02	AC1919	£21.00	——
Low level input panel inc. manual	STB-TC	£421.00	£399.95
Spare Manual for STB-TC	AC1920	£21.00	——
Connecting/daisy chain cable	CAB-01.	£34.00	£32.30

MS-DOS Drivers — ANALOG DEVICES

Software interface routines running under MS-DOS or PC-DOS that support the RTI-800 Series boards. These machine language routines provide analogue I/O, digital I/O, frequency input, event counting and pulse output functions, and are callable from the following languages:

Microsoft MACRO Assembler	Microsoft FORTRAN
Microsoft Compiled Basic	IBM® interpreted Basica
Microsoft C	IBM® Compiled Basic
Microsoft Pascal	Borland TURBO Pascal

Their are two packages, Order Code AC1527A covers the RTI-800, 802, 815, 817, 820, the other, Order Code AC1526A covers the RTI-850 and 860. They both includes calibration routines in software, on 5¼" floppy disks, disk documentation, and Analog Devices software single-user license. Spare manuals are available for both.

Note: These packages are only suitable for use with Analog Devices product.

	Order Code	Price Each
Driver for RTI-800, 802, 815, 817 and 820, inc. manual	AC1527A	£251.00
Spare manual	AC1526A	£21.00
Driver for RTI-850, and 860 inc. manual	AC1527B	£166.00
Spare manual	AC1526B	£21.00

LABTECH Notebook — LABORATORY TECHNOLOGIES CORP.

- No programming required
- Up to 300 mixed I/O points
- Fast fourier transforms & curve fit
- Real time data streaming
- Real time display
- Interfaces to programmes like Lotus 1-2-3

This is a general purpose software package for data acquisition, monitoring, and real time control. It comes complete with a range of software drivers that allow it to operate with all RTI-800 series boards.

The package has the unusual capability of operating as a real time multitasking subsystem running under PC/MS-DOS. This allows a complex schedule of data acquisition and control to be carried out whilst running another application program simultaneously.

The range of software drivers supplied with LABTECH Notebook are available separately. These are for existing users of LABTECH Notebook who only need the drivers to work with the RTI-800 series boards. Includes 5¼" Floppy disks, documentation and single-user license.

Note: These packages are only suitable for use with Analog Devices product.

	Order Code	Price Each
LABTECH Notebook inc. manual	AC1530	£848.00
LABTECH Notebook software drivers	AC1529	£85.00

LABTECH Real Time Access — LABORATORY TECHNOLOGIES CORP.

- Can be used with Popular spread sheets & Data Bases.
- Provides real time data acquisition into application programme.
- Provides real time modification of Notebook's process control environment.

For use with LABTECH Notebook, Rev. 3.0 and up. Allows a DOS application programme running in the 'foreground' to access the real time data being acquired simultaneously by LABTECH Notebook running in the 'background'. Includes 5¼" Floppy disk, documentation, and single-user license.

Note: This package is only suitable for use with Analog Devices product.

Order Code	Price Each
AC1909	£251.00

UnkelScope Level 2 Plus — UNKEL SOFTWARE

- Emulates an oscilloscope, chart recorder or X/Y plotter.
- Process Control capability.
- Three trigger modes.
- FFT and power spectrum analysis.
- Technical report generation.

Menu-driven data acquisition software that turns the IBM® PC XT AT or compatible into a data logger/oscilloscope. Extensive real time data processing features are included, enabling data to be read and processed by spreadsheets, database programs or by any programming language. Includes 5¼" Floppy disks, documentation, and single-user license.

The packages support the RTI-800, 815, and 820 boards.

Note: This package is only suitable for use with Analog Devices product.

Order Code	Price Each
AC1507	£467.00

ASYST Scientific Software — ASYST SOFTWARE TECHNOLOGIES

- Supports multiple RTI boards
- Supports IEEE 488 communication
- Up to 256 channels per application
- Multiple graphic windows
- Built in analysis function

Advanced set of data acquisition, analysis and statistical functions for laboratory and scientific use. The packages consist of a number of interlinkable modules:-

Module 1	System, graphics, and statistics functions.
Module 2	Analysis functions.
Module 3	Data Acquisition functions, and RTI-800 Series Drivers.
Module 4	IEEE 488 Communication.

Two versions are available, one without IEEE 488 communications, Order Code AC1902, and one with IEEE 488 communications, Order Code AC1903. Both include 5¼" Floppy disks, documentation, hardware key, and single-user license.

The packages support the RTI-800, 802, and 815 boards.

Note: These packages are only suitable for use with Analog Devices product.

	Order Code	Price Each
ASYST Modules 1, 2, 3	AC1902	£1780.00
ASYST Modules 1, 2, 3, 4	AC1903	£1952.00

SNAPSHOT Storage Scope — HEM DATA CORPORATION

- Acquisition of up to 16 channels
- Display up to four channels in near real time
- Magnitude displayed in engineering units
- Data files can be read by Lotus 1-2-3
- Replay data from disk and display graphically
- Write data to display, disk or printer

Menu-driven software that provides IBM® PC XT or AT based data acquisition and analysis with the power of a storage oscilloscope. Functions provided include data acquisition, disk acquisition, disk storage, graphical display, cursor and table analysing tools and interface to spread sheet and statistical analysis packages. Includes 5¼" floppy disks, documentation and single-user license.

SNAP-CALC, allows high level calculations on data acquired via SNAPSHOT. It is only available as a package with Snapshot. Includes 5¼" floppy disks, documentation and single-user license.

Supports RTI-800/815/850/860.

Note: These packages are only suitable for use with Analog Devices product.

	Order Code	Price Each
Snapshot storage scope	AC1911	£425.00
Snapshot storage scope and SNAP-CALC	AC1913	£757.00

Snap-FFT — HEM DATA CORPORATION

- Provides power spectrum analysis
- Calculates up to 8182 points
- Plots results on linear or LOG scale
- Converts time domain to the frequency domain

Frequency spectrum analysis package for use with SNAPSHOT STORAGE SCOPE, Order Code AC1911. Includes 5¼" Floppy disk, documentation and single-user license.

Note: This package is only suitable for use with Analog Devices product.

Order Code	Price Each
AC1912	£412.00

Control EG — [illegible]

- Up to 128 analogue inputs
- Change displays 'on the fly'
- High and low level alarms
- PID control
- Data logging to disk and printer
- Real time scheduler

Advanced, menu-driven software package, combining data acquisition and process control functions of data loggers, programmable controllers and PID controllers into a spreadsheet-like format. Easy to set up tabular and graphic displays. Includes 5¼" floppy disks, documentation, and single-user license. The packages support all the RTI-800 series boards.

Note: This package is only suitable for use with Analog Devices product.

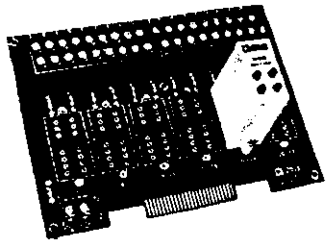
Order Code	Price Each
AC1904	£425.00

continued

6

Digital Signal Conditioning – DB24 Subsystem

ANALOG DEVICES



The DB-24 digital I/O panel provides sockets for up 6 plug in solid state relay modules* (opto-isolators) which provide the interface between high voltage external inputs and outputs and the TTL signal levels required by the RTI-800, 815, 817 and 820 boards. Each module handles 4 channels of the same type, offering up to 24 channels of isolated digital I/O. The state of each input or output can be observed from the 4 LED's on each module.

Power requirements	+5V, 50mA (max) per relay module.
	+5V, 300mA (max) fully populated system.
Common mode isolation voltage	4000V rms input to output

DB-24 INPUT MODULES

Range	Turn on time	Turn off time	Input current	OrderCode
4–16V dc	50uS	100uS	45mA**	ID16FQ
10–32V dc	5mS	5mS	25mA	ID32Q
15–32V ac				
90–140V dc	20mS	20mS	11mA	IA120Q
90–140V ac				
180–280V dc	20mS	20mS	7mA	IA240Q

**15mA at +5V

DB-24 OUTPUT MODULES

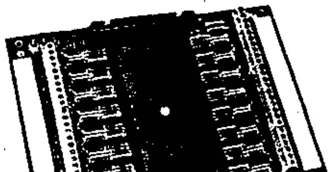
Range	Turn on time	Turn off time	Input current	OrderCode
12–280V ac	1/2 cycle	1/2 cycle	3A*	OA240Q
5–60V dc	1000 uS	750 uS	3A*	OD60Q

*per channel at 20°C

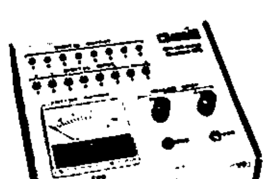
The RTI 800 Series boards will also interface to the Crydom solid state relays shown on **page 161.**

	Order Code	Price Each Per Quantity 1+	6+	24+
Opto Isolator panel	**DB-24**	£122.00	£115.90	£112.24
Input Modules				
4–16V dc	**ID16FQ**	£55.00	£52.25	£50.60
10–32V dc	**ID32Q**	£43.00	£40.85	£39.56
15–32V ac				
90–140V dc	**IA120Q**	£43.00	£40.85	£39.56
90–140V ac				
180–280V dc	**IA240Q**	£43.00	£40.85	£39.56
Output Modules				
12–280V ac	**OA240Q**	£43.00	£40.85	£39.56
5–60V dc	**OD60Q**	£43.00	£40.85	£39.56

Accessories and Publication Details



STB-GP



AC1518

AC1315	Cable for use with 5B Minifolds, 2ft 26 way cable with 2 female IDC socket connectors.
AC1324	Universal adapter board 26 pin commector input 26 screw terminal output.
AC1335	Interface cable for use with RTI-800, 815 and 5B01 Manufold.
AC1518	RTI-800 input/output signal simulator unit, includes cables and documentation. Is used in system prototyping.
AC15851-1	Analogue and digital I/O screw termination panel, includes cable. (Not compatible with RTI-802)
AC1585-2	Analogue I/O screw termination panel, includes cable. For use with RTI-802
AC158-3	Digital I/O screw termination panel for direct wiring applications using RTI-800, 815.
AC1585-9	Interface cable for use with DB-24 panel and RT-817, 820
AC1585-10	Interface panel and cables for use with DB-24 panel and RTI-800, 815.
AC1585-11	Interface cable for use with RTI-860, slits to 5B01 and AC1324 universal adaptor board.
IOB120-01	Interface panel and cable for use with RTI-800, 815 and two 5B01 manifolds (OA10 also required).
OA10	Multiplexer expansion for use with RTI-800, 815 increases number of analogue input channels from 16 to 32 single ended.
RM02	19" Rack mount kit for STB-GP, STB-TC and DB-24
STB-GP	Screw termination panel and cable for use with RTI-850, 860, includes open position matrix for user installed current shunts, resistor attenuators and low pass filters.
193-528	Comprehensive data and some application notes on all the RTI-800 series boards, DB-24, 5B modules and software. The RTI-200 boards are not covered but separate data sheets are available on request.
AC1364	Detailed user manual for the 5B analogue signal conditioners.

Order Code	Price Each Per Quantity 1+	5+
AC1315	£16.00	£15.20
AC1324	£34.00	£32.30
AC1335	£64.00	£60.80
AC1364	£21.00	—
AC1518	£383.00	£363.85
AC1585-1	£102.00	£96.90
AC1585-2	£102.00	£96.90
AC1585-3	£102.00	£96.90
AC1585-9	£30.00	£28.50
AC1585-10	£102.00	£96.90
AC1585-11	£64.00	£60.80
IOB120-01	£128.00	£121.60
OA10	£55.00	£52.25
RM02	£85.00	£80.75
STB-GP	£208.00	£197.60
193-528	£15.00	—

IBM - Compatible Software

Word

MICROSOFT

Word is a powerful, simple and easy to use word processor program. Its advanced features make it simple to produce top quality results.

The screen display is a true representation of what will be output by the printer. (a graphics card is required to display all available features). Tables of contents and indexes can be produced at the end of document production. Tables of figures can be mathematically manipulated using +, −, ×, ÷ and %. Lists and tables can be sorted by a number of different criteria.

Incorporated in the package are a 220,000 word, word finder thesaurus and an 80,000 word dictionary, spelling checker.

ASCII files can be used or produced.

The program supports over 120 types of dot matrix, daisy wheel and laser printers.

Word will function with Rbase, dbase and the microsoft Bus or Serial mouse.

Supplied on 3½" and 5¼" disks.

System Requirements. IBM® PC, XT, AT, PS/2 or compatible with 320K memory DOS 3.1 min, two double sided disk drives or one floppy disk drive and a hard disk.

Note: Version supplied will be the latest available. Contact Sales Office for details.

Order Code	Price Each
193-619	£395.00

Project

MICROSOFT

Project is a project scheduling and costing program that will work projects lasting days to 120 years with costs up to £21,000,000.

The program's aim is to give the project controller the correct costings and timings to achieve the stated goals. The program will accommodate scheduling ASAP, ALAP or date specific, resource costing, plan verses actual tracking, 'what if' analysis, resource use and activity reports, sort routines.

The maximum number of activities is memory dependent, the minimum system of 256K allows 100 activities to be monitored, each additional 64K will allow up to 200 additional activities.

The program includes an interactive 30 lesson training disk that takes the user through the essentials of project management, using Microsoft project.

Data can be exchanged using other programs such as: Chart, Multiplan, Lotus® 1-2-3, dbase II®, and Primavera project planner®. Data can also be input via ASCII files. The program supports mouse operation.

Supplied on 3½" and 5¼" disks.

System Requirements. IBM® PC, XT, AT, PS/2 or compatible, DOS 2.0+, 256K memory, two double sided disk drives or one with hard disk.

Note: Version supplied will be the latest available. Contact Sales Office for details.

Order Code	Price Each
193-616	£345.00

continued

Securicor 'A' Service available on request.

IBM Compatible Software — continued

Excel — MICROSOFT

Excel contains spreadsheet, database and charting facilities in an integrated package.

Maximum worksheet size is 16,584 rows by 256 columns.

Excels intelligent recalculation saves time by only recalculating cells which are affected by a number change. The powerful macro facility allows you to recall a commonly used sequence of keystrokes with a single command.

There are 131 built in functions available for use in calculations.

Presentation is easily controlled using up to four different fonts per sheet, variable row heights and column widths and shading. In addition 44 different types of chart are readily available for graphing data.

Excel can display worksheets and multiple charts on screen simultaneously and re-draws any charts automatically when underlying data changes.

The database facility allows the use of a spreadsheet as a database with fast searching, sorting and extracting of information.

The database format makes it easy to enter records, review the database and set search criteria.

Up to 16,383 records and up to 256 fields are allowed, depending on available memory.

Excel can also read/write files in many other formats including Lotus 1-2-3, dBase II, dBase III and Symphony Release 1.2.

Supplied on 3½" and 5¼" disks.

System requirements. IBM® AT, PS/2 or 100% compatible with 640K memory, DOS 3.0+, one double sided disk drive and a hard disk. Graphics adapter card, VGA, EGA, Hercules or compatible.

Version supplied will be the latest available. Contact Sales Office for details

Order Code	Price Each
193-629	£395.00

Works — MICROSOFT

Works combines word processing, database management, spreadsheets and communications in an easy to use program.

A computer based training program teaches how to use the package and can be used from within the main tasks to provide on-line help.

The word processor includes facilities for mail merging to create personalised letters and special pre-designed formats for printing mailing labels.

There is also a 100,000 word spelling checker and the facility to mix text with graphics or spreadsheets.

The spread sheet program has 57 built in functions and allows up to 256 columns by 4096 rows.

Split screen operation allows the user to view different parts of a large spread sheet simultaneously.

Eight different chart types are available for displaying data.

The database operates in form or list modes and can sort up to three fields. It can make use of the built in statistical and financial functions.

For communications, terminal emulation allows the user to access services such as Telecom Gold and Prestel.

In addition, VT52 and VT100 terminal emulation gives access to programmes on main frame and mini-computers.

An auto-log-on capability is provided and files may be transfered to other systems using X.Modem.

Supplied on 3½" and 5¼" disks.

System requirements: IBM®, XT, AT, PS/2 or 100% compatible with 384K memory, DOS 2.0+, two 360 disk drives or one 720K disk drive or hard disk drive. Graphics adapter cards (for charting) CGA, EGA, VGA or Hercules.

Note: Version supplied will be the latest available. Contact Sales Office for details.

Order Code	Price Each
193-627	£145.00

Chart — MICROSOFT

Chart is a complete business graphics program. It can derive data from Microsoft Multiplan, Lotus® 1-2-3, dbase II®, dbase III and many other application programs. It can output to screen or to 35 types of dot matrix printers, 17 plotters, 3 laser printers and 5 film recorders such as the Polaroid palette.

There is a built in gallery of 8 chart types, in 45 standard formats. Custom charts can be designed by the user and saved in a complete or data less format for future use. The standard chart types are, Area, bar, column, hi-lo, line, mixed, pie or scatter. Up to 12 fonts are available and the output can be in up to 177 colours (hardware permitting), in EGA operation up to 16 on screen colours may be used with a resolution of 640x350 pixels. Up to 16 charts can be put on a single page. When outputting to a plotter the tracking speeds can be adjusted to produce charts on transparencies for overhead projectors.

There are 8 built-in mathematical functions for data analysis, averages, cumulative, difference, growth (exponential curve fitting), maths (arithmetic combination of data series), percent, statistics and trend.

Supplied on 3½" and 5¼" disks.

System Requirements. IBM® PC, XT, AT, PS/2 or compatible with 320K memory DOS 2.0+, one or two double sided disk drives, with or without hard disk. Graphics adaptor card, CGA, EGA, Hercules or compatible.

Note: Version supplied will be the latest available. Contact Sales Office for details.

Order Code	Price Each
193-617	£250.00

Rbase System — MICROSOFT

Rbase System is a complete and sophisticated relational database management system. It offers capabilities normally associated with minicomputer and mainframe products while being easier to use than most microcomputer based packages.

Rbase system is both single and multi user, it can be used equally on a stand alone 'PC' or on most popular local area networks. An unlimited number of users are permitted per package per network file saver, additional sets of manuals are available.

The system uses a conventional structure but places very few of the constraints on data size, content and complexity normally associated with a microcomputer product. Data is stored in up to 80 tables. A table contains one 'row' (record) for each file entry, which in turn is divided into 800 columns (fields). Row number is limited only be accessable memory.

Extensive facilities are available for the production of customised screen and print out documents. data only forms can also be produced, this is a menu driven programme generator that allows non-programmers to produce custom applications. A translator is incorporated that converts applications to a binary file which increases speed and prevents unauthorised inspection or modification. A full screen editor is built in, together with a complete menu driven import/export facility to exchange data with other applications.

All popular data formats supported. These include Lotus 1-2-3®, Symphony, dbase® II, III and III Plus, SYLK (multiplan), DIF (Visicalc®), PFS File, ASCII (delimited on fixed field length).

Supplied on 3½" and 5¼" disks.

A trial pack is available, this is a full specification programme that has been record limited. It allows the potential user to evaluate the Rbase system at at his leisure.

System Requirements. IBM®, PC XT, AT, PS/2 or 100% compatible was hard disk, DOS single user 2.0+, 512K RAM, Multiuser (on LAN) 3.1+, 640K RAM. The system will operate with any 40 to 256 column ASCII printer compatible with the users system.

Note: Version supplied will be the latest available. Contact Sales Office for details.

	Order Code	Price Each
Rbase system	193-604	£545.00
Additional manual sets	193-605	£60.00
Rbase trial pack	193-606	£25.00

Multiplan — MICROSOFT

Multiplan a single user on network spreadsheet program which can accommodate very complex work sheets with up to 4095 rows by 255 columns (1,044, 225 cells) and work sheets can be linked to give virtually unlimited computing power.

The program has built in debugging facilities and auditing with pass word protection and data encryption. ASCII files can be read from micros, mini computers or mainframes combined with the ability to read/write to Lotus 1-2-3® or SYLK files. Documentation can be time and/or date marked in a variety formats. Printing enhancements include custom headers, footers and page numbers. Column sorting can be carried out by alphabetical or numerical rules. Data can be transferred to Microsoft Chart to produce presentation quality graphics.

The screen display features include: Dynamic screen height from 11 to 43 lines with EGA support, on screen display of up to 8 worksheets at one time, individual column widths up to 64 characters, or screen display of formulae or values.

Multiplan has a complete library of financial, statistical, mathematical, text and logical functions, it also supports maths co-processors 8087 and 80287.

With Multiplan Network, individual worksheets can be dynamically linked so that any change made to one will automatically be reflected in the others, even over a network system.

Multiplan is mouse compatible making movement around the worksheet simple. Information can be passed between multiplan, chart, word and project. For network users additional manuals are available.

Supplied on 3½" and 5¼" disks.

System Requirements. Single users: IBM® PC, XT, AT, PS/2 or compatible. 256K memory, DOS 2.0+, one double sided disk drive or one double sided disk drive+hard disk. Network users: 256K memory. DOS 3.1+ on each workstation and a file server with a hard disk and one double sided disk drive.

Note: Version supplied will be the latest available Contact sales department for details.

	Order Code	Price Each
Multiplan single user	193-601	£150.00
Multiplan network	193-602	£395.00
Additional manuals	193-603	£60.00

Securicor 'A' Service available on request.

Windows and Windows/386 — MICROSOFT

Windows turns your personal computer into a multi-tasking multi application working environment.

The windows graphical environment significantly simplifies the use of multiple application programs.

The drop down menus, dialogue boxes and icons, make sharing text and graphics amongst programs simple and efficient.

Windows also looks like the presentation manager that will be the user interface of OS/2, the operating system for IBM's next generation of personal computers.

There are two distinct versions of Windows, Windows 2.0 and Windows/386. They are identical to use and in presentation, they differ in the host computer that they run on and the number of tasks they can run is limited only by that host computer.

Windows 2.0 is designed to run on 8088/8086 based computers such as the IBM® XT, AT PS/2 model 30 on compatibles. You can work with many programs at a time instead of just one. Most existing DOS applications take over the entire screen, yet you can still switch to windows and back again. Some applications such as dBase III PLUS, can be run in a window making it simpler to switch from program to program. No matter what applications are in use selected information can be copied and transferred between them.

Windows/386 is designed to run on computers using the Intel 80386 processor, just as the COMPAQ DESKPRO 386 or IBM PS/2 Model 80, or equipped with an Intel Inboard 386/AT.

Windows/386 exploits the computing power and multi-tasking capabilities of the 80386. It can control multiple DOS applications within their own 640K '8086' environment, any number of tasks can be handled dependent only on available memory space.

Windows/386 supports programs written to use the Lotus-Intel-Microsoft (LIM) expanded memory manager without the need for expanded memory hardware, it uses the memory mapping capabilities of the 80386 to emulate the LIM interface. Full support is provided for the Intel 80387 mathematics co-processors.

Both Windows 2.0 and Windows/386 are supplied complete with the following applications:-

Write. Easy to use word processor designed for day-to-day personal and business tasks. Integrate information from standard applications; adjust fonts, type styles, other printing characteristics. What you see on the screen matches what you'll get on paper. File compatible with Microsoft Word (meaning that Window Write can read Word files, and Word can read Windows Write files).

Windows Paint. Drawing program for illustrating everything from reports to announcements. Add highlights to charts created in standard applications. Drawing tools include lines, circles, rectangles, patterns, text, font styles and sizes, freehand figures.

MS-DOS Executive. File management program. Provides access to common DOS functions, even while you're running other programs. Drop-down menus and dialogue boxes give easy access to common commands such as running a program, copying a disk, copying a file, creating directories, setting volume names.

Appointment Calendar. Day or month view. Multiple built-in alarms; can be set to ring at any minute. More than one calendar file can be maintained simultaneously, for keeping track of more than one person's appointments. Displays current time, date.

Calculator. Convenient calculator for performing quick calculations. Answers can be pasted into application programs. Memory function. Enter data from keyboard or pointing device. Standard math functions. Square root. Percentage.

Cardfile. Rolodex style cardfile. As flexible as using 3"×5" index cards. Accepts both text and graphics. Autodial from any phone number on cards (requires Hayes or a compatible modem). Automatically sort, search, edit and add cards. Display as cards or as a list of topline information. Copy text to and from applications, or between cards.

Clock. Analogue clock displays time; continues to show correct time even when it's shrunk into an icon.

Notepad. A text scratch pad and simple text editor for jotting down notes. Time-stamping option lets you maintain a log of your work.

Clipboard. Clipboard program allows you to review current contents of information cut or copied from other applications. Clipboard function is built into windows.

Reversi. Intriguing and challenging game. A comfortable way to get aquainted with some windows basics.

Control Panel. Set system parameters, install printers or change printer configurations. Reset time, date, screen colours, cursor blink, speed of mouse click.

Terminal. Communications program. Send or receive information, even while using other programs. Copy information and paste into application programs. Adjust standard communications parameters, such as baud rate, communication port, and phone type. Autodial feature works with Hayes or compatible modems, such as the 176-255 shown in Section 30.

Print Spooler. Work on one file while you are printing another. Available from any printable Windows application.

Program Information File (PIF) Editor. Create and edit files that allow Microsoft Windows to run standard applications at maximum efficiency.

RAMDrive. Can set any portion of memory – such as a memory expansion card – an easy to access fast performing RAM disk.

Windows 2.0 is supplied on either 3½" or 5¼" floppy disks package separately.

Windows/386 is supplied on both 3½" and 5¼" floppy disks in a combined package.

System Requirements:

Windows 2.0. IBM® XT, AT, PS/2 or compatible, 512K of memory, DOS 3.0 or higher.
One double sided 5¼" floppy disk drive and one hard disk drive (recommended) or one double sided 360K 5¼" disk drive and one 1.2Mb 5¼" disk drive.
For 3½" based systems one 720K 3½" disk drive and hard disk drive is recommended but 2×720K 3½" drives are acceptable.
Graphics card, Hercules monochrome, EGA, VGA or compatible.

Windows/386. A 386 based personal computer such as the COMPAQ DESKPRO 386 or IBM PS/2 model 80.
1Mb of memory 2Mb is recommended, DOS 3.1 or higher. One 1.2 Mb 5¼" or 1.4Mb 3½" disk drive together with a hard disk with 2Mb of available space.
Graphics card, COMPAQ graphics adaptors, EGA, VGA or compatible.

	Order Code	Price Each
Windows 2.0 – 3½" disks	193-628	£75.00
Windows 2.0 – 5¼" disks	193-620	£75.00
Windows/386 – 3½" and 5¼" disks	193-626	£150.00

Windows Draw — MICROSOFT

Windows Draw is a presentation graphics and drawing program that runs under Microsoft Windows. It is considerably more sophisticated than 'Paint' which comes as standard with Windows. Graphics produced on draw can be transported to 'Paint' or 'Write'.

Draw benefits greatly by running under windows, it uses pull down menus and dialogue boxes that speed familiarity and virtually eliminated the need to refer to manuals. Common commands have their functions duplicated on single key strokes, speeding use for experienced users. Draw does not use a conventional 'Bit map' as a storage method. Draw is 'Object' orientated. This means a circle is stored as an item in its own right with designated characteristics ie, diameter, line width, colour, fill, radius centre. This allows an object to be modified at any time, with any of its characteristics being individually accessible.

Draw will produce drawings up to 34"×34" (large drawings point across multiple sheets of paper). Multiple drawings can be viewed and edited, zoom in or out, display actual size. User definable grid/ruler scale in inches or centimetres with a grid lock for accurate technical drawing. There are many lines and shapes available with colour when an EGA is fitted.

Draw will input Lotus® 1-2-3 and symphony graphs, with each element of the graph being treated as a separate object.

Supplied on 5¼" disks.

System Requirements. IBM® PC, XT, AT or compatible, Windows, DOS 2.0+ 320K memory. Two double sided disk drives or one plus a hard disk. Graphics adaptor card. EGA minimum for colour.

Note: Version supplied will be the latest available. Contact Sales Office for details.

Order Code	Price Each
193-610	£145.00

Macro Assembler — OS/2 Code Compatible — NEW — MICROSOFT

Macro Assembler is a complete development environment for MS-DOS assembly language programming.

Assembler code can be developed and maintained for the Intel® 8086 and 80286. There is full support for the 8087 and 80287 maths co-processors. The package comprises the following tools; Macro assembler, symbolic debug utility, object code linker, library manager, cross reference utility, program maintenance utility,.EXE file compression utility,.EXE file header utility.

The assembly rate is 9000 lines per minute on an IBM® AT, data is accepted in binary, decimal, octal and hexidecimal format. The symbolic debug facility allows screen swapping between debug and user screens. The debug utility can be used for source-level debugging of programmes written in Microsoft C compiler, FORTRAN, and Pascal as well as for viewing the disassembly, breakpoints and single stepping are supported.

The object code linker will link Macro assembler routines to programs written in Microsoft C compiler, FORTRAN, Pascal, GW-BASIC, QuickBASIC and COBOL.

System Requirements. IBM® PC, XT, AT, PS/2 or compatible, 256K available user memory, (320K recommended) (MS-DOS 'CHKDSK' will determine available space,) DOS 2.0+, OS/2 1.0+two double sided disk drives, or one double sided disk drive and one hard disk, 8087 or 80287 optional.

Note: Version supplied will be the latest available. Contact Sales Office for details.

	Order Code	Price Each
Macro assembler on 5¼" disks	193-618	£115.00
Macro assembler on 3½" disks	193-634	£115.00

C Compiler — MICROSOFT

The C Compiler is a full implementation of the UNIX system V, C language which includes many ANSI features and support for all proposed ANSI libraries. Microsoft C is also both source and object code portable, between the MS-DOS and XENIX® 286 operating systems. In addition interlanguage linking allows the user to call sub-routines written in Microsoft FORTRAN, Microsoft Pascal or Microsoft Macro assembler from those in Microsoft C or vice versa.

The package includes, Microsoft Code View a source level windowing debugger. It supports multiple memory models, small, medium, compact, large and huge. It has the ability to mix models using near, far and huge pointer. Programs up to 1 Megabyte and arrays greater than 64K bytes can be produced. The package will support the 8027/80287 maths co-processors with emulation support together with IEEE single and double precision real numbers. Under MS-DOS 3.1+ with Microsoft Networks 1.0 or under IBM® PC network, Microsoft C Compiler supports multi-user network access with both file and record locking. Start up code is incorporated for easier creation of ROM resident code.

The package has to be used in conjunction with the Microsoft Mouse.

Supplied on 3½" and 5¼" floppy disks.

System Requirements. IBM® PC, XT, AT, PS/2 or compatible 385K memory DOS 2.0+, Two double sided disk drives or one plus a hard disk.

Note: Version supplied will be the latest available. Contact Sales Office for details.

Order Code	Price Each
193-621	£345.00

continued

IBM® Compatible Software — continued

QuickBASIC Compiler — MICROSOFT

QuickBASIC is a fast BASIC compiler. It has a comprehensive full screen editor an enhanced integrated debugger and full 8087/80287 maths co-processor support.

The debugger can trace up to 26 errors during a compilation without interrupting the compilation process, when complete the debugger highlights the errors line by line. The debugger also has single step, animate and trace modes, variables can be displayed during debugging. The compilation process is fast, up to 12,000 lines per minute on an IBM® AT.

The compilation can take place totally in memory or stand alone code can be produced, compilation parameters can be set up to optimise say, speed or size. Macro assembler routines can be linked to the main program in speed sensitive sections.

QuickBASIC supports the 8087/80287 co-processors, but if at run time these devices are not present the program automatically reverts to a full IEEE 80-bit emulation. When co-processors are not available Microsoft Binary maths routines offer fast 64 bit floating point processing.

Modular programming is supported for separate compilation with full global or local variables. Direct access to the DOS and BIOS interrupts are supplied with the user library.

QuickBASIC will compile IBM BASICA and Microsoft GW-BASIC with minor or no modification, it will also run with ProKey, SideKick and SuperKey.

System Requirements. IBM® PC, XT, AT, PS/2 or compatible, 320K memory, DOS 2.0+ one double sided disk drive optional Bus or Serial mouse.

Note: Version supplied will be the latest available. Contact Sales Office for details.

	Order Code	Price Each
QuickBASIC on 5¼" disks	193-623	£75.00
QuickBASIC on 3½" disks	193-635	£75.00

BBC Basic (86) — M-TEC

BBC Basic can now be used on a PC® compatible running MS-DOS®, or equivalent. Almost all the features of BBC Basic are available, including:

- Multi-lined named procedures and functions
- In-line assembler using standard mnemonics
- Serial, random and indexed disk files plus the ability to access any byte in the file
- VDU commands, graphics, sound
- Full screen editing

Any differences between BBC BASIC (86) and Acorn BBC Basic are purely due to the hardware limitations of the PC®. Within these hardware limitations BBC Basic (86) has been designed to be as compatible as possible with Version 4 of the 6502 BBC Basic resident in the BBC Micro 'Master' Series.

Please Note:

- Apart from *FX15 (flush KB), FX calls are not implemented
- Only one sound channel
- Graphics screen is 0-1279 points wide, 0-799 points high
- In-line assembler is 8086/8088
- MODE's are slightly different (Telex mode is not available)

Mode	Pixels	Output	Columns × Lines
0	640 × 200	2 Colour Display	80 × 25
1	320 × 200	4 Colour Display	40 × 25
2	320 × 200	4 Colour Display	40 × 25
3	None	16 Colour Text Only	80 × 25
4	320 × 200	4 Colour Display	40 × 25
5	320 × 200	4 Colour Display	40 × 25
6	None	16 Colour Text Only	40 × 25
7	None	Monochrome Text Only	80 × 25

Modes 0 to 6 are only available if PC® compatible colour/graphics adaptor is fitted.
Mode 7 is only available if PC® compatible monochrome adaptor is fitted.

- 32 Colours available (including highlight)
- VDU commands 0-31 and 127 available
- More flexible file handling
- Access to MS-DOS using ★ commands or OSCLI (BBC BASIC will execute BBC BASIC (86) from within your own application program).
- LIST IF command to search program and list occurrences of specified string.
- Full screen edit. Scrolling backwards and forwards through program, eliminating need to continually list.

Order Code	Price Each
193-158	£95.00

Pascal Compiler — OS/2 Code Compatible — NEW — MICROSOFT

Pascal Compiler is a powerful systems development language that allows programmers to create highly readable modular, and transportable code. Pascal has a clean block structure and procedure orientation. It is well suited for many systems software programming tasks.

The package is based on proposed ISO and ASNI standards to ensure language compatibility. Microsoft Pascal source code is compatible across the XENIX 286 and MS-DOS operating systems.

Large programs are supported, up to 1 megabyte under MS-DOS or 1.3 Megabyte under XENIX. Separate module compilation allows a library of routines to be produced and then linked together. Low level escapes are included which allows programmes to access assembler routines or memory locations directly.

Sub routines written in Microsoft C compiler and FORTRAN can also be incorporated.

The package supports the 8087/80287 maths co-processors and also allows emulation of these devices, should they not be present. For speed critical applications where co-processors are not available an alternative 15 digit BCD maths library can be selected.

Supplied on 5¼" disks.

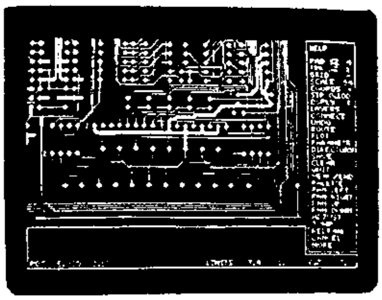
System Requirements. IBM® PC, XT, AT or compatible, 320K available user memory (512K recommended) MS-DOS 2.1+, or OS/2 1.0 or higher, two double sided disk drives, or one double sided disk drive plus a hard disk.

Note: Version supplied will be the latest available. Contact Sales Office for details.

	Order Code	Price Each
PASCAL on 5¼" disks	193-636	£235.00
PASCAL on 3½" disks	193-637	£235.00

PCB Turbo Version 2. Autoroute PCB Design Software — INSTAGRAPHIC

For use on the IBM® PC, AT or XT



- Manual or automatic track routing
- Runs on IBM® PC, XT or AT (or compatible)
- Plotter or printer output
- Schematic drawing facility
- Component library
- Window facility allows any part of the drawing to be moved, copied or erased
- Runs with standard colour monitor with Colour Graphics Adaptor (CGA) or Enhanced Graphics Adaptor (EGA)

The PCB Turbo has been upgraded with many major and minor changes. some of the more significant changes are:- support of Enhanced Graphics Adaptor (EGA) for improved resolution, support for the Gerber photoplotter output format, and the ability to print artworks on Epson dot matrix printers. A full list of changes can be obtained via a data request or by telephoning our Technical Sales Department.

The PCB Turbo program is a sophisticated printed circuit board design package which will enable the the user to produce artwork for single or double sided printed circuit boards up to a maximum size of 24" × 24".

An autorouting facility allows automatic routing of tracks from a 'ratsnest' of direct lines via either one or both sides of the board. Alternatively tracks may be placed manually by marking point to point with the input device being used. The last track drawn may be repeated any number of times.

The program will run on the IBM® PC XT, or AT computer or any machine which is truly IBM compatible and has a minimum of 640Kbytes RAM and a serial port. A colour monitor with the relevant colour graphics adaptor (CGA) or extended graphics adaptor (EGA) is also required. It is possible to use a monochrome monitor as part of the system, however in this case the different layers of the board will be presented as varying shades of grey.

Artworks are laid onto the screen using a selectable 0.1" grid. Pads and tracks can be placed on a 0.005" minimum spacing therefore a very high packing density is possible. Components may be placed at desired locations within the specified board outline, either by drawing them on the screen or by extracting them from a component library. Newly-created components may be named and saved as library parts.

Any part of the drawing screen may be erased, copied, moved or saved on disk by placing a window around the area required. Full panning and zoom facilities are incorporated and six levels of screen magnification are available. Nine sizes of round or square pad and nine sizes of track may be defined by the user and placed on one or both sides of the board.

A full schematic drawing facility enables the user to draw lines, boxes, arcs and circles to create silk screen overlays or circuit diagrams. Text may be selected from three sizes and placed either on the silk screen layer or in copper.

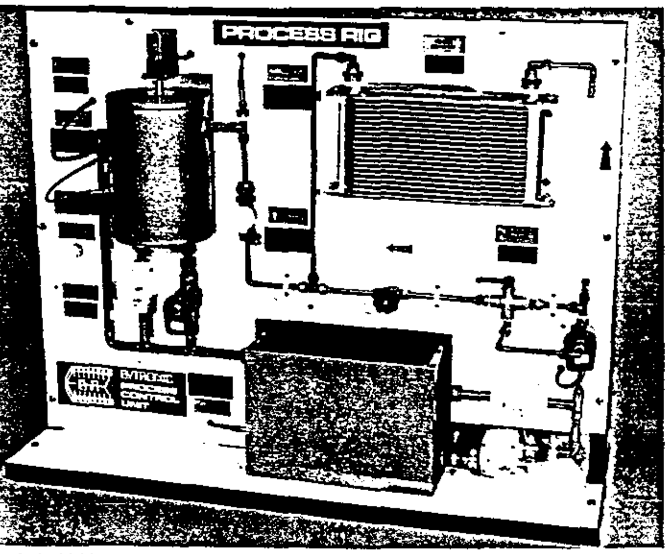
The completed design may be sent to an HPGL compatible pen plotter, Gerber compatible photoplotter or an Epson compatible printer to produce artworks for each side of the board plus silk screen ident, solder mask and drilling template. A Quickplot for checking purposes may also be produced. Cursor control is via the keyboard, Microsoft Bus mouse or trackerball.

An upgrade is available for Version 1. Any person who has purchased the Version 1 program (193-168) since 1st January 1988 will receive the upgrade free of charge. For purchases before this date the upgrade is chargeable. To obtain the upgrade, whether chargeable or not, the original Version 1 'Datakey' must be returned with a written order, telephone orders will not be accepted for the upgrade package.

FOR A SUITABLE PLOTTER 176-841 OR 176-096 SEE **PAGE 144**
FOR A SUITABLE MOUSE 177-530 SEE **PAGE 107**
FOR A SUITABLE TRACKER BALL 176-923 SEE **PAGE 156**

	Order Code	Price Each
PCB Turbo Version 2	193-180	£695.00
Upgrade for 193-168 (Version 1)	193-181	£195.00

PROCESS CONTROL TECHNOLOGY



ade in U.K. 910 · 730 · 340mm

Complete training package for Process Control and Instrumentation.

Interfaces to BBC+, IBM PC & Clones.

Interfaces to Programmable Logic Controllers.

Flow, Temperature & Adaptive Control.

Interactive Program for Studying Three Term PID Control.

User Defined System Parameters.

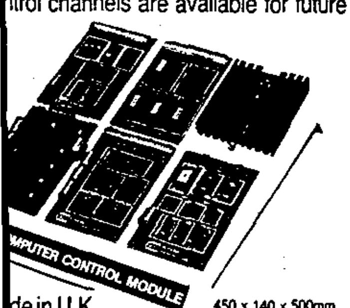
Real-Time Response Graphs and System Mimics.

Data Logging – Stores Response Graphs for Later Analysis.

Student Accessible Software plus Programming Exercises.

Supplied Complete with User Manual & Student Exercises.

ıe Process Control Unit (PCU) is a unique, benchtop system for aching both the theory and practice of a microprocessor controlled stem using three term PID control.
ıe PCU is supplied as a complete training package and comprises a ocess Rig, Computer or PLC Interface Module, Power Supply, eractive Software and User Manual.
ıe Process Rig features a variable speed pump, heating element, oler, 4 meter displays, 5 indicator displays, 2 solenoid valves, stirrer d float switch. Feedback is provided by a flowmeter and 3 Platinum sistance Temperature sensors. For comparison, manual control cilities are also provided.
erface Modules are available which connect the Process Rig to either a C, IBM PC or to a Programmable Logic Controller. Full access is provided the various interfacing boards enabling a study of signal conditioning, tput driving, ADC, DAC and analogue power control. Several unused ntrol channels are available for future expansion or student project work.



de in U.K. 450 × 140 × 500mm

A suite of Interactive Programs allows quick set up and running of a process cycle.
Proportional, Integral and Derivative values are defined by the user who can study the systems response to differing set point, load or step change conditions. The response may be shown as a graph, system mimic or printer output. A data logging facility is also provided.

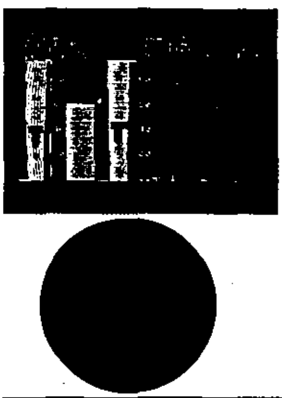
omprehensive manual provides details of the system plus several trol experiments. Using these, students can investigate different thods of determining a system's performance and how a three term troller is developed. **FACT SHEET P1**

C INTERFACE MODULE
s module enables a PLC to control the PCU. A unique, universal nination board allows virtually any PLC offering a minimum of 4 logue inputs and 2 analogue outputs plus 8 digital I O lines to be used. ıg this module control programs can be developed in ladder logic format.

RDERING INFORMATION:

ESCRIPTION		CODE	PRICE
ocess Control: Complete BBC Package		PCU1	£5145
ocess Control: Complete IBM PC Package		PCU2	£5285
ocess Control: Complete PLC Package		PCU3	£4443
U Modules e available parately	Process Rig Module	PCSR1	£2995
	BBC Interface Module	PCCM1	£1652
	IBM Interface Module	PCCM2	£1792
	PLC Interface Module	PCPLC1	£950
	Power Supply Unit	PCPS1	£498

COMPUTER BASED LEARNING FOR PROCESS CONTROL



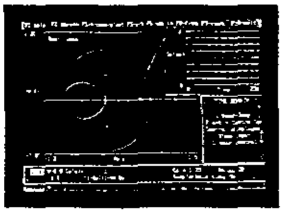
CBL-3 provides an excellent introduction to process control. Each CBL package is supplied with a Student Workbook and Program Disc which is divided into several interactive tutorials. Each tutorial uses a combination of system mimics and response graphics to illustrate the control of fluid level.

The effect of different lags on step, ramp and sine wave disturbances, on-off control, deadband and finally PID control are described. Users learn at their own pace and on completion will be able to tune a three term controller with confidence. **FACT SHEET P2**

ORDERING INFORMATION:

DESCRIPTION	CODE	PRICE
BBC Single User Licence	CBL3BB	£295
BBC Multi-User Licence (6 Users)	CBL3BB6	£650
BBC Additional Licences (per Computer)	CBL3BX	£95
IBM Single User Licence	CBL3PC	£395
IBM Multi-User Licence (6 Users)	CBL3PC6	£850
IBM Additional Licences (per Computer)	CBL3PCX	£125

CODAS II PROCESS DESIGN & SIMULATION



Superb package for modelling control systems. Allows transfer functions to be defined in terms of operator 'z' and 's'.
New features include:
- Discrete time systems.
- Global Parameters.
- Non-Linearities, Disturbances.
- Non-Unity Feedback Systems.
- Regulator Performance.

ORDERING INFORMATION: **FACT SHEET P3**

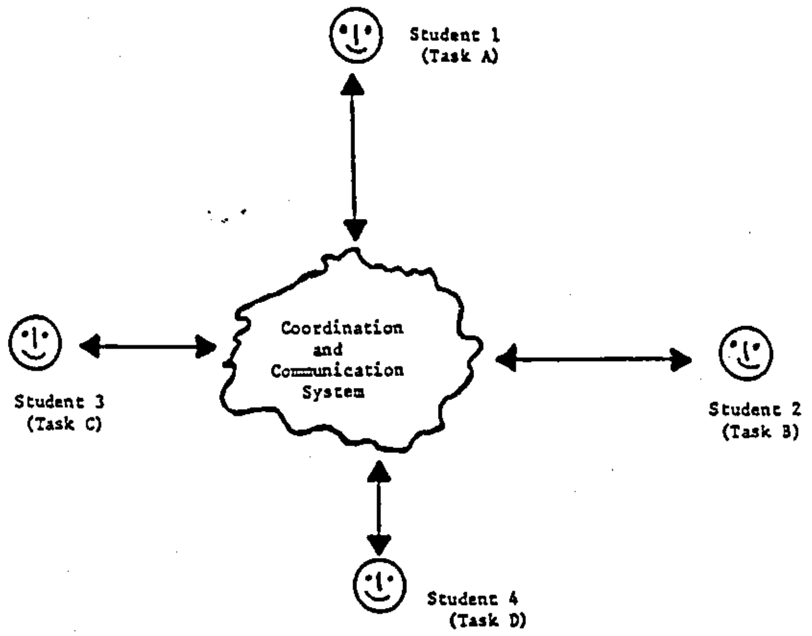
DESCRIPTION	CODE	PRICE
IBM Single User Licence	CODAS2PC	£475
IBM Multi-User Licence (8 Users)	CODAS2PC8	£600
IBM Additional Licences (per Computer)	CODAS2PCX	£45

Made in U.K.

TABLE 5.1 - TYPICAL EXAMPLES OF AUTHORING TOOLS

Authoring system	*Runs on*	*Colour*	*Links with other media*	*Student interface*	*Multi-user network*	*Student management*	*Notes*
MENTOR II PMSL Mentor	Sirius IBM PC	No 16 from palette of 128	Videotape Videodisc Audio	Light pen Mouse Touch pen Standard keyboard	Stand-alone	Yes	Compatible with machines running on UCSD-p
MicroPLATO Control Data	Viking Zenith IBM PC	No 16 from palette of 256	Videotape Videodisc Audio	Touch screen Graphics tablet Special keyboard	Stand-alone and Network	Yes	New product enhancements expected soon
Micro TICCIT Training Technology	DG mini + IBM PC	Palette of 4096	Videotape Videodisc Audio	Lightpen Touch screen Special keyboard	Network	Yes	Underlying instructional strategy
REGENCY Rediffusion Simulation	REGENCY Micro	16 from palette of 256	Videotape Videodisc Audio	Touch screen Graphics tablet Special keyboard	Network	Yes	Good simulation facilities
WISE WICAT Systems	WICAT Micro	16 from pallete of 256	Videodisc Audio	Touch screen Graphics tablet Standard keyboard	Multi-user and Network	Yes	Lesson delivery soon available on IBM PC

(A) Distributed Group Learning



(B) Centralised/Localised Group Learning

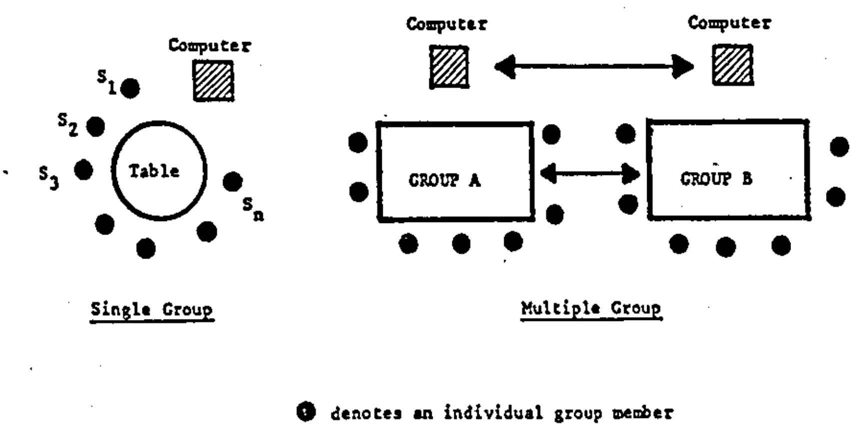


FIGURE 5.23 - TYPICAL APPROACHES TO GROUP LEARNING WITH COMPUTERS

(a) Ability to operate in both an autonomous mode and a networked environment
(b) Provision of support for a variety of human–computer interaction techniques
(c) Ability to cater for both line and frame oriented dialogues
(d) Provision of good frame-editing facilities
(e) Caters for the provision of graphics, animation, and audio
(f) Capable of providing highly end-user oriented interfaces, that is, it must be user friendly and easy to use
(g) Capable of providing adequate database and knowledge base support facilities
(h) Able to capture broadcast (radio and TV) material from global distribution systems
(i) Provides support for a variety of information storage media
(j) Able to create dynamic models of individual students and to use these to produce highly individualised instructional schemes
(k) Capable of incorporating standards (where they exist) in order to facilitate the exchange of instructional material
(l) Ability to produce generic material that can be easily modified to meet different requirements
(m) Capable of providing an extensible environment that is able to accommodate unforeseen advances in technology and user requirements
(n) Capable of being made highly reliable and of being easily maintained by local technicians
(o) Able to provide facilities to support parallel simultaneous tasks (through multi-tasking and multi-processing)
(p) Able to support inter-task communication with parallel activities
(q) Capable of providing facile control of the learner's interaction environment.

TABLE 5.2 - REQUIREMENTS FOR AN AUTHORING ENVIRONMENT

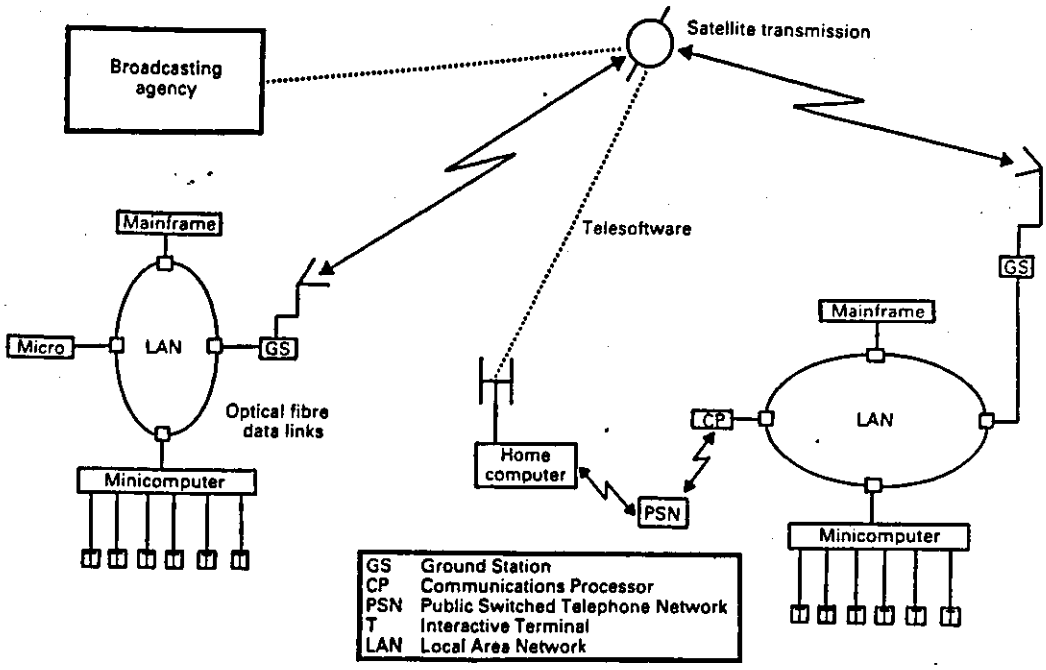


Figure 1.13 A computer based open learning system for CAL.

FIGURE 5.24 - A COMPUTER BASED OPEN LEARNING SYSTEM FOR CAL

APPENDIX 6

Consideration	*Interview*	*Questionnaire*
1. Personal need to collect data	Requires interviewers	Requires a clerk
2. Major expense	Payment to interviewers	Postage and printing
3. Opportunites for response-keying (personalisation)	Extensive	Limited
4. Opportunites for asking	Extensive	Limited
5. Opportunities for probing	Possible	Difficult
6. Relative magnitude of data reduction	Great (because of coding)	Mainly limited to rostering
7. Typically, the number of respondents who can be reached	Limited	Extensive
8. Rate of return	Good	Poor
9. Sources of error	Interviewer, instrument, coding, sample	Limited to instrument and sample
10. Overall reliability	Quite limited	Fair
11. Emphasis on writing skill	Limited	Extensive

TABLE 6.1 COMPARISON OF INTERVIEW AND QUESTIONNAIRE METHODOLOGIES

Interview Questionnaire.

1. What subject areas and level do you teach?
2. What teaching/learning methods do you utilise?
3. What type of computer do you use in your teaching and for what purpose?
4. What programming language do you favour?
5. What do you understand by computer assisted learning?
6. Do you use it?
7. If not why not?
8. Are you likely to use it, be prepared to use it if forced to, or are interested in using it?
9. If you use it how do you utilise it in your classes?
10. What types of software have you used with the classes you teach?
11. What future trends would you like to see develop in terms of CAL usage?
12. What are your main areas of interest in using software?
13. What do you think of the present quality of software available for your areas of work?
14. What are the main features you look for in CAL software packages to deem them good quality?
15. General Comments.

TABLE 6.2 INTERVIEW QUESTIONNAIRE

Principal: Rosemary Gray
Director of Education: Mrs D M Tuck

Walsall College of Technology St Paul's Street, Walsall WS1 1XN

Telephone: (0922) 720824
Telex: 335927 WALCOT G
Fax: (0922) 29967

DIVISION OF TECHNOLOGY

Dear

With reference to our telephone conversation of the 25th May 1989 concerning my MSc dissertation on Computer Assisted Learning. Many thanks for agreeing to allow your staff to participate.

If possible, could you forward the names of staff willing to participate in interviews, and the days and times of the week when they are available. All staff must be teaching on BTEC National and/or Higher National Certificate courses in Electrical/Electronic Engineering. The number of staff not willing to participate would also be an helpful .. statistic. I have enclosed an attached sheet with the times when I am available to conduct the interviews, but I can alter these to suit, given prior notice.

I would like to stress that all interviews will be in the strictest confidence, and that the completed dissertation will bear no reference to any individual or College. Also a copy of the dissertation will be sent to yourself and may be disseminated amongst your participating staff and other interested parties as you see fit.

If you could let me have the information requested above as soon as possible, if will be a great help in planning my overall visiting strategy to the various Colleges.

Once again, many thanks in anticipation of your co-operation.

Yours sincerely,

(DENNIS HEATH)

FIGURE 6.1 - COVERING LETTER TO CONFIRM SURVEY

COLLEGE CONTACT ADDRESS :

MR. D. HEATH
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
WALSALL COLLEGE OF TECHNOLOGY
ST. PAUL'S STREET
WALSALL
WS1 1XN
WEST MIDLANDS

TEL NO : (0922) 720824

HOME TEL NO : (05436) 73602

TIMES AVAILABLE TO CONDUCT INTERVIEWS

MONDAY	2.30 - 4.30	EVERY WEEK UNTIL END OF SUMMER TERM
TUESDAY	9.00 - 11.00	
WEDNESDAY	ALL DAY	
FRIDAY	2.00 - 4.30	

FIGURE 6.1 (CONTINUED)

Case studies have a number of advantages that make them attractive to educational evaluators or researchers. Thus:

1. Case study data, paradoxically, is 'strong in reality' but difficult to organise. In contrast, other research data is often 'weak in reality' but susceptible to ready organisation. This strength in reality is because case studies are down-to-earth and attention holding, in harmony with the reader's own experience, and thus provide a 'natural' basis for generalisation.
2. Case studies allow generalisations either about an instance or from an instance to a class. Their peculiar strength lies in their attention to the subtlety and complexity of the case in its own right.
3. Case studies recognise the complexity and 'embeddedness' of social truths. By carefully attending to social situations, case studies can represent something of the discrepancies or conflicts between the viewpoints held by participants. The best case studies are capable of offering some support to alternative interpretations.
4. Case studies, considered as products, may form an archive of descriptive material sufficiently rich to admit subsequent reinterpretation. Given the variety and complexity of educational purposes and environments, there is an obvious value in having a data source for researchers and users whose purposes may be different from our own.
5. Case studies are 'a step to action'. They begin in a world of action and contribute to it. Their insights may be directly interpreted and put to use; for staff or individual self-development, for within-institutional feedback; for formative evaluation; and in educational policy making.
6. Case studies present research or evaluation data in a more publicly accessible form than other kinds of research report, although this virtue is to some extent bought at the expense of their length. The language and the form of the presentation is hopefully less esoteric and less dependent on specialised interpretation than conventional research reports. The case study is capable of serving multiple audiences. It reduces the dependence of the reader upon unstated implicit assumptions ... and makes the research process itself accessible. Case studies, therefore, may contribute towards the 'democratisation' of decision-making (and knowledge itself). At its best, they allow the reader to judge the implications of a study for himself.

FIGURE 6.2 - ADVANTAGES OF THE USE OF CASE STUDIES

APPENDICES 1

INDUSTRY AND SOCIETY SYLLABUS

B/TEC Business & Technician Education Council

Form A5

Application for Approval

Centre-devised Unit/Subject

National Diploma NE04
(Elect + E'nic Eng)

Date: DECEMBER 1986

Unit number: if already allocated

Centre number	20845
Centre name	WALSALL COLLEGE OF TECHNOLOGY
Unit/subject title	INDUSTRY AND SOCIETY
Value	1.0
Instruction/Learning support time	60 hours
Level/Stage/Year	N
Prerequisites	NONE
Co-requisites (to be studied in parallel)	NONE
Exemptions	NONE

Summary of Aims

The aims of this unit are to enable the student to:

(a) Understand how people are involved in relationships within industry and their role as consumers.

(b) Understands how industry is financed and organised

(c) Understands the nature of industrial strategies in a time of increasing technological change.

Assessment scheme

100% Assignments Model H.

Other courses in which this unit/subject appears

If the course is being submitted concurrently, leave the last column blank

Award and title	Course/Application No

Teaching and Learning strategies	1	Learning is essentially student-centred within a structured framework. Wider participation will be sought wherever possible in order to incorporate work-related problems.
	2	This unit is supportive to the core studies as a vehicle for integration. Students should be encouraged to think for themselves wherever possible, with centre staff adopting a monitoring/counselling role.
	3	It could be helpful to hold critical analysis sessions to highlight common and individual deficiencies in content/presentation of students' work and allow group discussion resulting from this.
Assessment scheme	1	The scheme will have 100% assignments based on BTEC Model H.
	2	Some of the assignments will require oral presentation which will supplement the written and graphic work.
	3	The weighting of each section of the unit is shown under the Principal Objectives.
	4	The assessment of the unit will be based upon a comprehension of the Principal Objectives together with an understanding of how to plan, communicate, implement, evaluate and present assignment work.
Special Notes	1	Assignments will be defined within the aims and objectives of each section of the unit thus coordinating the assessment scheme overall.
	2	The nature and scope of assignments will reflect the nature of employment associated with the course.
	3	The number of assignments will reflect the depth and breadth indicated by the aims and objectives.
	4	The philosophy outlined in this unit will form the basis of the approach to all assignments and particularly those components of each unit which combine to form the integrative assignments.
	5	Communication skills are expected to form part of the assessment in all sections of the unit. These will include oral, written and graphic skills and information retrieval.

Section		Principal Objectives plus indicative content or specific objectives
A	Relationsips in industry. (20%)	1 Understands the nature of industrial relationships in the workplace. (a) Considers the aspirations of people at work. (b) Compares rights and obligations between firms and employees. (c) Appreciates the structure, aims and methods of trade unions and employers' organisations. (d) Recognises the role of government in industrial relations.
B	The Consumers and Producers. (20%)	1 Understands the relationship between consumers and producers. (a) Appreciates the different methods of buying, selling, borrowing and saving. (b) Comprehends Consumer Protection. (c) Evaluates the effect of advertising on buying and selling. (d) Compares rights and obligations between consumers and producers.
C	Finance and Organisation (20%)	1 Understands how industry is financed and organised. (a) Comprehends various forms of business organisations in the contect of the mixed economy. (b) Appreciates how these organisations are funded. (c) Examines the role of Government and its funding of the mixed economy.
D	Industry and Change. (20%)	1 Understands the impact of technology on society. (a) Appreciates technological change and how it affects . organisation and work practices . Economic development . environment . leisure . employment

E	National and Regional Industrial Policies (20%)	1	Understands the nature of industrial development in the context of local and central government policies. (a) Appreciates the role of Government on national industrial strategy. (b) Recognises the regional policy for industry in the West Midlands. (c) Understands how international conditions affect industry.

APPENDICES 2

ENGINEERING APPLICATIONS OF COMPUTERS SYLLABUS

B/TEC Business & Technician Education Council

Unit Number
U86/328

Standard Unit

Unit title	Engineering Applications of Computers
Value	0.5
Learning support time	Typically 30 hours in respect of a part-time course (where it is complemented by work-based experiential learning) with up to 45 hours being more usual in full-time courses.
Level	NII
Prerequisites	None
Co-requisites (to be studied in parallel)	None
Exemptions	None

Summary of aims

To provide an important part of the central focus for the development and integration of skills and knowledge relevant to the student's present and future role as a Technician and to enable the student to:

a appreciate the use of computers in engineering industries;

b understand the operation of a computer system;

c recognise the role of utilities and applications packages in computer systems;

d appreciate the importance of the man-machine interface;

e recognise the differences between, and applications of, high and low level languages;

f use applications packages on a computer to carry out specified engineering tasks.

Teaching/learning strategies

1 When designing implementation strategies, teaching staff should consult the appropriate course guidelines. Guidance provided in the specifications of other core units should also be considered.

2 Consideration should be given to the integration of objectives, particularly *section E*, into the rest of the programme by using the computer appropriately in engineering assignments relating to other units.

3 Emphasis should be placed upon the development of learning activities designed to ensure that students gain experience of the practical applications of computers in engineering contexts, so that the aims and principal objectives will be achieved.

Assessment scheme

1 Assignments and other assessment devices should be planned in such a way as to identify clearly the knowledge and skills that are to be assesssed.

2 In order to gain a pass grade for the unit the student must achieve the learning outcomes expressed by the principal objectives. A student would not normally be awarded a pass grade without achieving a satisfactory level of competence in relation to all the skills and knowledge expressed by the specific objectives under principal objectives A to D.

3 In *section E*, the emphasis is on the application of skills and knowledge introduced by earlier objectives. The student must demonstrate competence in running application packages to achieve specified tasks, following a logical sequence of steps. The teacher's appraisal of the whole process and of the degree of success of the student in achieving each step will contribute to the overall assessment of the student. It is suggested that at least 50% of the total unit assessment is by assignment work centred round *section E*.

4 *Section E*, including both principal objectives 5 and 6, must be completed successfully in order to pass the unit. It is expected that the assignment reports will be used to assess other skills and knowledge, including communication skills. In such cases it may be appropriate to extend reports beyond the minimum required for the assessment of objectives 5 and 6 only.

Special notes

1 Approximately one third of learning support time should be set aside for *sections A* to *D* and approximately two thirds should be allowed for *section E*.

2 Parts of objective 4a will best be achieved by practical demonstrations on a computer/microprocessor system (for example speed, memory space).

3 Under *section E* the verb 'use' is intended to include loading of programs (where appropriate), operation of the system and the display and recording of results (where appropriate).

4 Before the student commences assignment work under *section E*, the system to be used by the student should be identified by the teacher and discussed with the student.

5 Learning should be largely or wholly assignment based. To achieve this the tutor should plan a series of assignments to cover the content of the unit.

6 The level of the unit is defined by the objectives but the design of learning activities, including assignments, should take into account the stage of development and other experience of the student.

College Ref. N02

B/TEC
Business & Technician
Education Council

Unit Number
U86/328

Unit Title ENGINEERING APPLICATIONS OF COMPUTERS

Value 0.5

Level N II

Special Notes 1. The content for this unit together with relevant learning support time is detailed below.

2. The content used is

*delete as applicable

*(a) a non-amended version of the standard unit.

*(b) ~~an amended version extracted from the identically titled standard bank of objectives.~~

IDENTI-FICATION LETTER	TITLE OF SECTION	PRINCIPLE OBJECTIVE No.	SPECIFIC OBJECTIVE LETTERS	LEARNING SUPPORT TIME %
A	Industrial Applications of Computers	1	a - b	9%
B	Computer Systems	2	a - f	13%
C	utilities and Applications Packages	3	a - e	9%
D	High and Low Level Languages	4	a - b	9%
E	Use of Computer Systems in Engineering	5	a - h)	60%
		6	)	
Assessment:	Unit Assignments 25%			
	Integrative Assignments 25%			
	End of Unit Test 50%			

Section	Principal Objectives plus indicative content or specific objectives
A Industrial applications of computers 9%	1 Understands the factors governing the selection of a computer system for a particular engineering application.

a Compares the characteristics of a computer to be used in fields of:

- process control
- computer aided design
- computer aided manufacture
- simulation and prediction
- quality control
- routine stores control
- routine financial control
- storage and retrieval of records.

b Explains the multiple role of the computer in engineering as a controller, data processor and as a source of management information with particular reference to I/L interface requirements.

B Computer system 13%

2 Understands the hardware and software of a basic computer system and the inter-relationship.

a Uses a block diagram of a computer system to explain the function of the following hardware components:

- the CPU
- the store
- input/output interfacing
- peripherals/transducers/controllers
- interconnecting buses.

b Discriminates between, and identifies the main characteristics of, main memory and back-up memory.

c Distinguishes between Read/Write and Read Only Memory.

d Explains the importance of non-volatile memory in certain engineering applications.

e Explains that a program of machine code instructions, software or firmware, causes information to be routed between the CPU, the memory, the interfaces and peripherals.

B Computer system operation

f Identifies the characteristics of typical peripherals employed in a computer system.

C **Utilities and applications packages**

9 %

3 Analyses the use of utilities and applications packages.

a Explains the need for an operating system.

b Uses the commands of a simple monitor/operating system to CREATE, SAVE, DELETE, etc files.

c Distinguishes between systems software (utilities) and applications software.

d Discusses the advantages of user friendly software eg a menu driven system, to improve the man-machine interface.

e Explains the necessity of user friendly hardware for transfer of information to or from the computer eg joysticks, mouse.

D **High and low level languages**

9 %

4 Analyses the use of high and low level languages.

a Compares a high level language instruction with its equivalent assembly and machine code instructions with reference to:

- ease of programming
- speed of execution
- amount of memory required to store
- cost.

b Explains the functions of an assembler, an interpreter and a compiler.

E **Use of computer systems in engineering**

60 %

5 Uses commercial or pre-prepared software/firmware packages to simulate techniques appropriate to the student's discipline.

a Uses a computer system in an elementary on/off control situation eg temperature or level control.

b Uses a computer system to control a sequence of physical operations eg the sequential control of pneumatic/ hydraulic valves and actuators or the use of a Programmable Logic Controller.

c Uses a computer system to sort materials or components.

d Uses a CAD/CAM system to carry out an operation appropriate to the student's occupation.

e Uses a computer system to perform a simple engineering administrative task eg scheduling or stores control.

f Uses a computer system to perform a simple process control task eg data logging or PID control.

g Investigates the use of computers in a communication system eg satellite tracking and control, control of an exchange, interfacing between a peripheral and an exchange, control of a switching system, cellular radio, packet switching, frequency tracking and aerial tracking.

h Uses a computer system to perform some task other than those in *a* to *g* but which is particularly appropriate to the student's occupation.

6 Writes a report on each of the assignments selected from *5* above to incorporate:

- hardware requirements
- I/O interfacing requirements
- man-machine interface (effectiveness, ease of use, ruggedness, presentation of output).

TABLE 6.3 - PLAN OF LESSONS FOR ENG APP OF COMPUTERS

STUDENTS	WEEKS									
	1	2	3	4	5	6	7	8	9	10
GROUP A	SORT	WP	MOTOR	CAD	WP	ROBOT SIMULATION	SEQ	BUGGY	WP	ASSIGN 5
GROUP B	SEQ	WP	BUGGY	ROBOT SIMULATION	CAD	WP	SORT	MOTOR	WP	ASSIGN 5
GROUP C	MOTOR	CAD	WP	SORT	ROBOT SIMULATION	BUGGY	WP	SEQ	WP	ASSIGN 5
GROUP D	BUGGY	ROBOT SIMULATION	SORT	WP	SEQ	MOTOR	CAD	WP	WP	ASSIGN 5
GROUP E	CAD	BUGGY	WP	SEQ	MOTOR	WP	BUGGY	SORT	WP	ASSIGN 5
GROUP F	WP	SORT	ROBOT SIMULATION	MOTOR	BUGGY	SEQ	WP	CAD	WP	ASSIGN 5
GROUP G	ROBOT SIMULATION	MOTOR	SEQ	WP	SORT	CAD	BUGGY	WP	WP	ASSIGN 5
GROUP H	WP	SEQ	CAD	BUGGY	WP	SORT	MOTOR	ROBOT SIMULATION	WP	ASSIGN 5

PLAN OF TEACHING ASSIGNMENTS

WP - WORDPROCESSING
CAD - ASSIGNMENT N°2
SEQ - SEQUENCER ASSIGNMENT N°4
SORT - SORTER ASSIGNMENT N°3
MOTOR - D.C MOTOR CONTROL

WALSALL COLLEGE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

No. of sheets	Assignment
1 of 2	No. 2

COURSE TITLE		COURSE CODE NO	
SUBJECT/UNIT TITLE	IND. APP. OF COMPUTERS	SUBJECT CODE	U86/328
TOPIC TITLE	USE OF CAD	SYLLABUS REF.	Ed
ISSUED BY	R. TILSTON	DATE	09/01/89

Using the CAD system provided make a copy of the diagram issued. You should make use of the standard library components, magnifying and rotating as necessary. Your diagram should include your name in the bottom right hand corner.

When your diagram is complete(or when the session ends) you should save your diagram to disk, and print out the result.

You should then write an account of the use of the CAD system explaining what commands, keys, and devices you used. Also what problems you have experienced and how you think the system could be improved,

Finally, compare the system to what you would find in industry in terms of speed, quality, facilities, hardware etc.

FIGURE 6.11(a) - ASSIGNMENT No.2

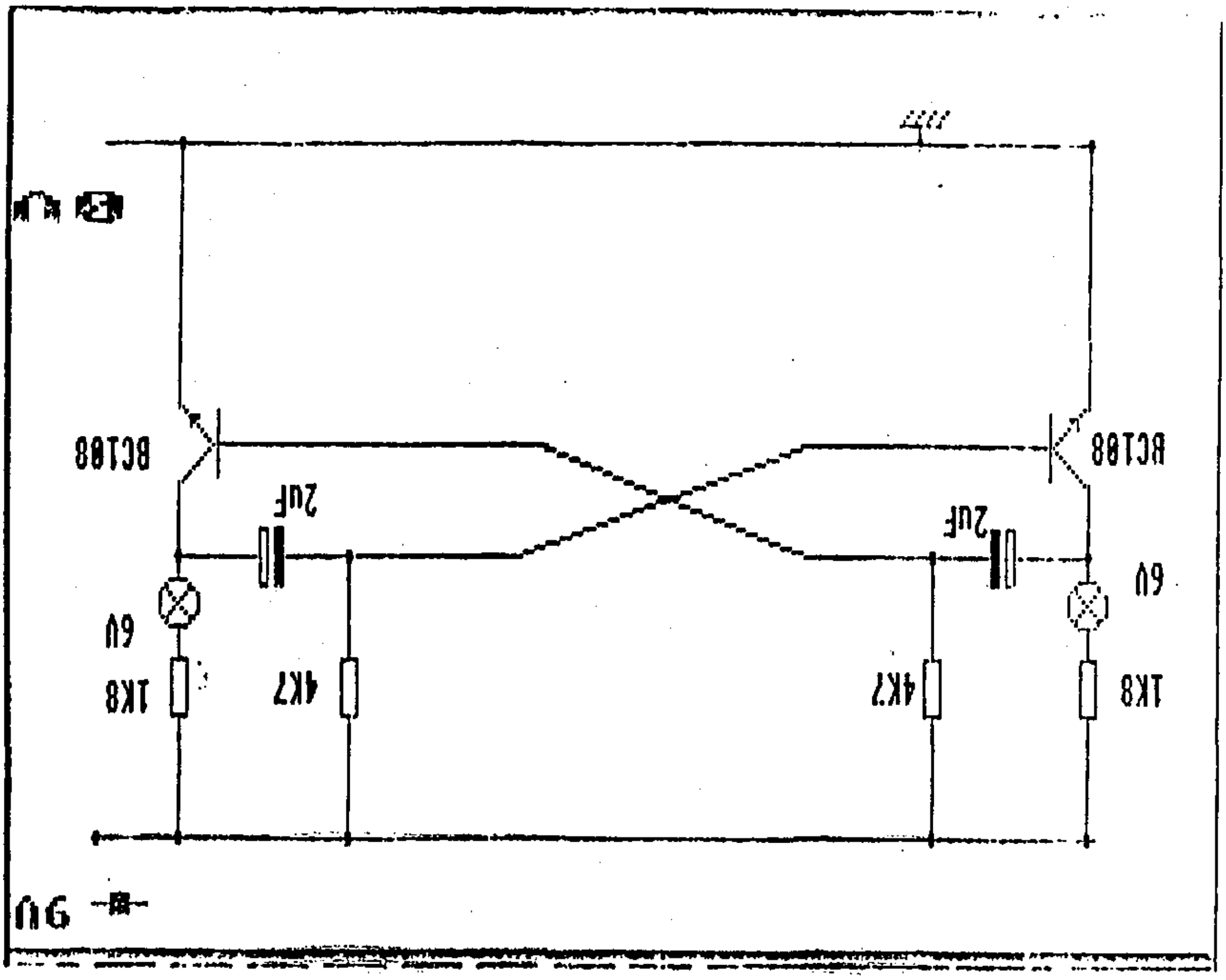


FIGURE 6.11(b) - PRINT OUT OF CIRCUIT FOR ASSIGNMENT No.2

WALSALL COLLEGE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

No. of sheets
1 of 1

ASSIGNMENT No.
3

COURSE TITLE		COURSE CODE No.	
SUBJECT/UNIT TITLE	INDUSTRIAL APPLICATIONS OF COMPUTERS	SUBJECT CODE	U86/329
TOPIC TITLE	USE OF COMPUTER TO SORT	SYLLABUS REF.	Ec
ISSUED BY	R. TILSTON	DATE	30.11.87

BEAD SORTER

Using the software and hardware provided, examine the Bead Sorter package. Utilize all options available in the menu and experiment with time delays and entry of your own parameters.

Note down how the system works, comment on each method of operation and the user friendliness of the system. Finally consider what types of industry this system would be best suited to and, for those students in employment, how you might be able to utilize this system at your place of work. (Either in your department or any other).

FIGURE 6.12 - ASSIGNMENT No.3

WALSALL COLLEGE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

No. of sheets 1 of 1

ASSIGNMENT No. [illegible]

COURSE TITLE		COURSE CODE No.	
SUBJECT/UNIT TITLE	INDUSTRIAL APPLICATIONS OF COMPUTERS	SUBJECT CODE	U86/329
TOPIC TITLE	USE OF A COMPUTER TO SEQUENCE.	SYLLABUS REF.	E6
ISSUED BY	R. TILSTON	DATE	30.11.87

PNEUMATIC SEQUENCER

Using the software and hardware provided, examine the Pneumatic Sequencer package. Utilize all options available in the menu and experiment with time delays and entry of your own parameters.

Note down how the system works, comment on each method of operation and the user friendliness of the system. Final consider what types of industry this system would be best suited to and, for those students in employment, how you might be able to utilize this system at your place of work. (Either in your department or any other.)

FIGURE 6.13 - ASSIGNMENT No.4

WALSALL COLLEGE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

No. of sheets 1 of 2	Assignment No. FINAL

COURSE TITLE		COURSE CODE NO	
SUBJECT/UNIT TITLE	Engineering Applications of Computers	SUBJECT CODE	U86/328
TOPIC TITLE	Computer Systems, Utilities Languages and uses	SYLLABUS REF.	2,3,&5
ISSUED BY	R. TILSTON	DATE	19/1/89

The final assignment is to be completed under exam conditions within 90 minutes. The requirements for the assignment are

* IBM personal computer with two disk drives
* A text editor eg Wordstar
* Block diagram of a Microprocessor system (attached)
* One formatted diskette containing test and readme files
* One unformatted diskette

No notes are to be used and the student should return all paperwork and both diskettes at the end of the session.

ALL INSTRUCTIONS ARE ON THE WRITE PROTECTED DISKETTE.

TO READ INITIAL INSTRUCTIONS ENTER AT THE C> PROMPT

TYPE A:README <enter>

FIGURE 6.14 - ASSIGNMENT No.5

APPENDICES 3

ANALOGUE SYLLABUS NIII

Business & Technician Education Council

Unit Number
U86/332

Standard Unit

Unit title	Electronics
Value	As a guide, it is estimated that the material included in the bank is equivalent to three units (3.0).
Learning support time	The whole, therefore, represents 180 hours of study in respect of a part-time course (where it is complemented by work-based experiential learning) with up to 270 hours in full-time courses.
Level	NIII
Prerequisites	Electronics NII, Mathematics NII, Electrical and Electronic Principles NII
Co-requisites (to be studied in parallel)	Electrical and Electronic Principles NIII
Exemptions	None

Summary of aims

The aims of this unit are to enable the student to:

a achieve a high level of competence in applying modern electronic devices;

b select appropriate measuring and test equipment;

c test and evaluation electronic systems and devices against manufacturers' data;

d select appropriate components and parameters to implement specific functions.

Other aims should be defined by users according to material selected and in relation to other units and the aims of the programmes.

Teaching/learning strategies

1 Wherever possible an investigatory approach should be adopted and normally at least 40% of the learning support time should be devoted to practical laboratory-based activity.

2 Tests should be conducted with emphasis on the correct use of measuring instruments and techniques and with reference to appropriate objectives in other units.

3 The result of most test and design activity should be reported using the most effective and appropriate means. Whether formal, informal, written or oral, such reports may form the basis of assessment not only of objectives of this unit but also of communication and other skills.

Assessment scheme

1 Because of the practical nature of the unit, assignment work should be the main vehicle for assessment. An appropriate plan is 50% of total unit assessment devoted to assignment work and 50% to a structured end test assessing the student's knowledge across all principal objectives.

2 Alternatively, the above plan may be modified to include a phase test, in which case the end-test mark allocation may be reduced.

3 All programmes in the Electrical/Electronic/Communications/Computing area must include one major integrative assignment relating to objectives from at least three units. It is possible that the assignment may involve objectives from a unit formed from this bank.

Special notes

1 The unit comprises a bank of material from which centres may select principal objectives and associated indicative objectives.

2 Programmes in Electrical and Electronic Engineering should include principal objectives *13, 14, 15* and *16* in the selection unless these are covered elsewhere.

3 Centres are required to indicate the appropriate learning support time for each major section of material selected. As a guide, it is estimated that the material included in the bank is roughly equivalent to 3.0.

4 The emphasis throughout should be on the use of integrated circuits rather than discrete components.

5 The student should be encouraged to adopt a critical approach to testing and measurement techniques and the appraisal of results obtained.

Section	Principal Objectives plus indicative content or specific objectives
A Decibels	1 Uses logarithmic units to express measured values of gain and attenuation.
	a Explains the advantages of expressing power gain in logarithmic units.
	b Expresses voltage and current ratios in decibels.
	c Explains the need for reference levels (eg dB_m).
	d Solves problems using decibels.
B Amplifiers	2 Measures and reports on the characteristics and performance of power amplifiers.
	a Explains the difference between Class A and Class B operation and emphasises the advantages and disadvantages.
	b Describes the operation of a Class B power amplifier having a complementary output stage and single transistor driver stage.
	c Tests and reports on the amplifier described in *b*.
	d Tests the performance of a single-chip power amplifier against manufacturers' data.
	3 Determines the characteristics and performance of a small-signal tuned amplifier.
	a Describes the operation of a simple single-stage tuned amplifier.
	b Sketches and explains a typical frequency response diagram for the amplifier described in *a*.
	c Tests and produces a gain/frequency response curve for a simple single-stage tuned amplifier.
	d Uses the response curve obtained in *c* to determine the gain/bandwidth product of the amplifier, varies the gain of the circuit mentioned in *a* and notes the effect on the gain/bandwidth product.
	4 Investigates the operating characteristics of a linear operational amplifier in a number of configurations.
	a Compares the characteristics of an ideal linear operational amplifier with those of a practical integrated-circuit device by reference to manufacturers' data sheets.
	b Derives an expression for the voltage gain of a system comprising a high-gain amplifier with voltage feedback.
	c Explains the difference between positive and negative feedback.
	d Explains the effect of negative feedback on:

B Amplifiers

- gain
- gain stability
- bandwidth
- distortion and noise
- input and output impedance.

e Explains the operation of a voltage follower and derives expressions for the voltage gain and input resistance.

f Derives an expression for the voltage gain of an operational amplifier when connected in:

- inverting mode
- non-inverting mode
- summing mode
- difference mode.

g Uses manufacturers' data sheets to design one of the amplifiers described in *f*.

h Constructs and tests the amplifier in *g* and reports.

C Oscillators

5 Designs and tests a sinusoidal oscillator.

a Deduces that for sinusoidal oscillations 1-ßA must equal zero at only one frequency and describes methods used in practice to achieve this.

b Discusses the gain-phase relationship of an amplifier and its associated network to produce oscillations, including cases where amplifier phase-shift is not 0° or 180°.

c Explains the operation of a single-tuned-circuit oscillator and estimates its frequency of oscillation from a given formula.

d Explains the advantages of using crystal control in oscillators.

e Constructs and tests a simple Wien Bridge oscillator using an IC operational amplifier, referring to manufacturers' data.

D Pulse waveforms

6 Measures the characteristics of a pulse waveform.

a Defines and illustrates the terms:

- pulse width
- pulse amplitude
- rise time

D Pulse waveforms

- decay time
- overshoot
- sag
- repetition frequency
- mark to space ratio.

b Measures the characteristics of a pulse.

E Noise

7 Understands sources of noise and methods of reduction.

a Discusses sources of noise.

b Calculates signal to noise ratio in dB, given the signal and noise power.

c Discusses methods of reducing the effects of noise originating via radiation, distortion and thermal effects, etc.

<u>APPENDICES 4</u>

DIGITAL NIII SYLLABUS

F **TTl, CMOS and ECL gates** 8 Investigates the operation and characteristics of TTL, CMOS and ECL gates.

a Describes, with reference to a circuit diagram, the operation of a:

- TTL NAND gate
- CMOS NOR gate
- ECL OR/NOR gate.

b Explains the meaning and compares typical values of:

- propogation delay
- fan-in and fan-out
- supply voltage
- logic levels
- noise immunity
- power dissipation

with reference to the manufacturers' literature on TTL, CMOS and ECL gates.

c Explains the use of the following types of TTL:

- open-collector
- totem pole output
- Schottky.

F TTL, CMOS and ECL gates

d Determines the value of pull-up resistors to be used with an open-collector TTL gate.

e Investigates the operation of TTL and CMOS gates with respect to:

- loading effect on logic levels
- noise immunity.

G Combinational networks

9 Designs and tests minimised combinational networks using SSI gates.

a Deduces the truth tables for combinational systems with up to four variables.

b Explains that incompletely specified functions will contain don't care/can't happen conditions.

c Uses a Karnaugh map to obtain a minimised function and inverse function.

d Describes the problems that may be caused by hazards, and explains how static hazards may be eliminated.

e Designs, implements and tests a minimised static hazard-free combinational network using:

- NAND gates only
- NOR gates only.

H Sequential systems

10 Investigates the operation of circuits using MSI devices.

a Explains the reasons for using MSI devices.

b Distinguishes between synchronous and asynchronous operation.

c Explains the operation of master-slave and edge-triggered flip-flops.

d Investigates the operation of an MSI:

- 4-stage asynchronous binary counter
- 4-stage synchronous binary counter
- 4-stage BCD counter
- universal self-register, ie parallel/serial in, serial/parallel out.

e Explains the function and tests the operation of:

- a Schmitt trigger
- a monostable multivibrator
- an astable multivibrator

H Sequential systems

constructed from an operational amplifier/555 timer and external components.

f Explains the functions and tests the operation of commercial MSI:

- decoders and encoders
- multiplexers and demultiplexers
- code converters
- adders.

g Describes the operation and uses of the various types of ROM and the PLA.

h Constructs and tests combinational functions using a multiplexer, a ROM and a PLA.

I Display devices

11 Investigates the operation of display devices.

a Describes the operational characteristics of LED and LCD display devices.

b Describes the features of seven-segment, star-burst and dot matrix displays.

c Designs, constructs and tests a SSI circuit driving a seven-segment display.

d Connects commercially available displays and driver circuits to appropriate equipment and tests unit operation.

J A-D and D-A conversion devices

12 Investigate the operation of analogue-digital and digital-analogue conversion devices.

a Explains two methods of converting analogue signals to digital equivalents and compares their relative features.

b Investigates practically the charateristics of a commercially available A-D device with reference to manufacturers' literature.

c Explains one method of digital-analogue conversion.

d Investigates practically the characteristics of a commercially available D-A device with reference to manufacturers' literature.

APPENDIX 7

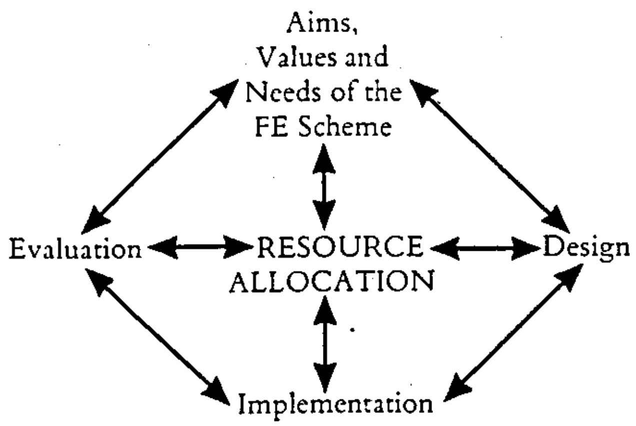


FIGURE 7.1 - MODIFIED FEU MODEL OF CURRICULUM DEVELOPMENT