A Study of a Mathematics Provision for First Year Engineering Undergraduates with Non-GCE A Level Entrance Qualifications

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ABSTRACT

There has been considerable interest in the teaching of mathematics to engineering undergraduates who have non-GCE A level entry qualifications. Several institutions have devised special provisions to provide support and help, where necessary, for such students in coping with mathematics at degree level. In Loughborough University of Technology, there have been significant efforts in designing mathematics courses that would suit Engineering undergraduates with varied entry qualifications, as there has been a marked increase of entrants with non-GCE A level qualifications in recent years.

This research programme, undertaken at Loughborough University of Technology, was an observational study of a particular mathematics provision for first year engineering undergraduates with non-GCE A level entry qualifications, with special attention to BTEC qualified entrants. The researcher has observed the development of the mathematics course for a full academic year and has produced a case study, theory and a model to provide description, explanation, evaluation and understanding of the processes involved.

For this research, an interpretive research perspective and qualitative methods have been adopted. The suitability of the methods have been discussed in the relevant sections. The main methods for collecting data were participant observation and interviewing, although other means of gathering data were employed, such as questionnaires and collecting documentation.

Analysis of the research data has enabled the researcher to modify and build on 'naturalistic' models of curriculum design and development. Recommendations for further research are included for future considerations.

Key words: Mathematics, Engineering, BTEC, Curriculum.

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LIST OF ABBREVIATIONS

1	BEC	Business Education Council
2	BTEC	Business and Technician Education Council
3	CAMET	Centre for the Advancement of Mathematical Education in Technology
4	GCE A Level	General Certificate of Education Advanced Level
5	HNC	Higher National Certificate
6	HND	Higher National Diploma
7	LUT	Loughborough University of Technology
8	OECD	Organisation for Economic Cooperation and Development
9	ONC	Ordinary National Certificate
10	OND	Ordinary National Diploma
11	SCOTVEC	Scottish Vocational Education Council
12	TEC	Technician Education Council
13	UCCA	Universities Central Council on Admissions
14	UK	United Kingdom
15	USA	United States of America

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CHAPTER 1

INTRODUCTION

The teaching of Mathematics to Engineering undergraduates has been given considerable attention in the past twenty years or so by teachers of higher education concerned with the Mathematics curriculum in Engineering Education at degree level (*vide infra* Chapter 2). In particular, much attention has been focused on the Mathematical ability and achievement of a sub-group of students, those with non-GCE A level entry qualifications, with particular reference to students with BTEC qualifications. This group of students has been consistently identified (*vide infra* 2.1) as having the most difficulty with Mathematics in Engineering degree courses.

This thesis will be describing a one year study of a Mathematics provision for first year undergraduate Engineering students, with non-GCE A level entry qualifications, at Loughborough University of Technology. The University has always been concerned with research into the Mathematical Education of Engineering students. In 1966, CAMET (Centre for the Advancement of Mathematical Education in Technology) was established. The Centre undertook significant research in this particular field. The special provision which is the subject of this study was set up in 1990 by the Mathematical Sciences Department with the collaboration of the various Engineering Departments of the University. The intention was to provide a separate Mathematics class for students with non-GCE A level Mathematics qualifications. These students were drawn from the different Engineering Departments of the University. Students with GCE A level qualifications were taught Mathematics by lecturers from the Department of Mathematical Sciences but they were grouped according to their own respective Engineering Departments. In the separate special provision for non-GCE A level entrants, the students were given more time to cover the same syllabus as that of the main departmental groups. Also, for the non-GCE A level entrants, there were smaller numbers of students in tutorial groups. The predominant non-GCE A level qualifications were BTEC (Business & Technician Education Council) certificates/diplomas from the United Kingdom and

Hong Kong. Some students had various overseas qualifications. Nevertheless, even though the research was conducted on a class of undergraduates with non-GCE A level entry qualifications, it was necessary to focus on the BTEC qualified students since, during the initial interviews conducted with various members of staff, the class was frequently called the 'BTEC Mathematics class'. It was also apparent that the majority of the students in the class had BTEC qualifications of various levels, III to V.

Although a significant number of other schemes and courses had been set up in the past at other institutions in the United Kingdom for such students (*vide infra* 2.1), these had been assessed more often than not, by variants of the scientific or rational educational research method. In the first instance, the researcher and other interested parties decided that it would be desirable and necessary, (i) to assess the effectiveness of the provision made for these students in Mathematics, (ii) to identify the problems faced by the teachers of Mathematics in teaching such students and (iii) to investigate the difficulties of the students themselves in coping with the Mathematics in the Engineering curriculum. In the event, as the research progressed and developed, these three aspects were combined and the study became essentially one related to curriculum design, development, implementation and evaluation. The decision to change the research focus was based on the initial analysis of the class observations, interviews with members of staff and the students. It became apparent that although the involved members of staff were concerned with students difficulties, their own attention was on the design and implementation of the Mathematics course. The students themselves who had a varied background in Mathematics and a wide range of mathematical abilities, were mainly concerned with how the course was to be taught and with the examinations (i.e. process and assessment).

After different research methodologies for curriculum study had been compared and considered, the researcher decided that it would be preferable to adopt a qualitative research perspective and methods which were considered more suitable for the subject of the research. By adopting a case study approach, together with the use of certain

ethnographic research methods, the researcher hoped to be able to provide a more comprehensive research study of the course and to enhance understanding and judgement of this particular curriculum innovation. The research perspective and methods have been described comprehensively in Chapter 3, but it would be helpful here to discuss the types of data and information which the researcher hoped to gather and how they might be used. LeCompte and Goetz (1984) identified three kinds of data that would be successfully provided by ethnographic research strategies. These were:

> *(1) Baseline data: information about the human and technological context of the research population and program setting. Social, psychological, cultural, demographic, and physical features of the context should be identified, both for assessing intervention impact and for establishing parameters that could affect generalizability to other settings and populations. The institutional framework and its relationships with other institutions should be examined for the variety of countervailing influences impinging upon change and stability.*
>
> *(2) Process data: information determining what happened in the course of a curricular program or innovation. The way the program or intervention and the evaluation was approached by participants provides data for assessing impact and success of an intervention.*
>
> *(3) Values data: information about the values of the participants, the program administrators, and the policymakers who financed the program, the values implications of an innovation, whose values the intervention supports and whose are neglected, may affect decisions about further dissemination.*
>
> (LeCompte and Goetz, 1984)

Some practitioners of qualitative research in Educational settings have discussed the positive and negative outcomes of teachers conducting classroom research (Woods, 1984; Delamont, 1981). In particular, they questioned the ability of these researchers to maintain their objectivity. Among the strategies suggested to develop and maintain an objective perspective is to conduct research in an

unfamiliar educational setting in an attempt to "*make the familiar strange*" (Delamont, 1981).

The researcher's interest in the problems faced by undergraduate Engineering students in learning Mathematics came from her own experience as an Assistant Lecturer in Universiti Teknologi Malaysia (Malaysia University of Technology) where she had taught Mathematics to Engineering students in Diploma and Degree courses. It should be noted that the Malaysia University of Technology Engineering courses is of three years' and five years' duration for the Diploma and Degree courses respectively as the students entry qualifications are at the Malaysian Certificate of Education level which are comparable to the GCE O level qualifications (Abdul Rahman, 1990). The researcher was very interested in conducting a study on students' feedback which would focus on their perspectives of their Mathematics learning.

In transferring the setting to a British university, the researcher considered that she would develop the objectivity required. Her unfamiliarity with the education in a local cultural context could be an advantage in that she would be unlikely to take for granted any events or experiences in the lectures and tutorials.

Chapter 2 will describe the importance of Mathematics in Engineering Education (*vide infra* 2.0). A review of some of the literature on the Mathematical learning difficulties of Engineering undergraduates will also be given. Descriptions of some special programmes and courses in Mathematics, for such students and other undergraduates, implemented in various institutions around the world will also be included (*vide infra* 2.1). The curriculum development of Mathematics in the Engineering Education curriculum at Loughborough University and the main factors influencing the current provision will also be discussed (*vide infra* 2.2).

Chapter 3 will explain the research perspective and methods that were adopted as well as the reasons for their implementation. A description of the analytical techniques that were used will also be presented.

In Chapter 4, data from the case study will be presented. To provide a background to the provision, a brief introduction to BTEC courses will be included to enable a greater appreciation of the group of students under study. Other data included are (i) interviews with members of staff which highlight the staff concerns and (ii) data collected from the students which presents and illuminates their views. A substantial record is also included of the research study of the class over one academic year. The aim of this research was not only to evaluate the curriculum innovation but also to enhance the understanding of the learning situation and the factors that influence its progress through the year. Chapter 4 essentially provides an illuminating picture of a curriculum in practice which, it is suggested, enhances understanding in a way which would not be achieved by merely studying curriculum plans, syllabuses and examination results.

In Chapter 5, a discussion of the theory emerging from the study is given. The researcher has found that data from this research builds on and firmly supports other theories on the naturalistic nature of curriculum development. Necessarily the analysis of the data was mainly conducted after the research was concluded but the adoption of a qualitative perspective meant that some analysis was made in the field. The theory and models therefore emerged as data was collected in the traditional manner of qualitative research. As a result this thesis presents a model of the curriculum development. The theory and model has been developed from the general framework of Armstrong's (1990) INSET Model of Curriculum Development but analysis of this research data suggests certain modifications to the latter model are necessary in order to explain, describe and illuminate the subject of this research study. The general conclusions of this research are also presented in Chapter 5 with recommendations for further research.

CHAPTER 2

MATHEMATICS IN ENGINEERING EDUCATION

2.0 Importance of Mathematics in Engineering Education

In the past 20 years, there has been considerable interest and research looking into the mathematical learning difficulties of Engineering undergraduates all over the world. In 1966, the OECD (Organisation for Economic Cooperation and Development) published a report entitled "The Mathematical Education of Engineers" which emphasised the importance of Mathematics in the education and training of Engineers. In the report, two core syllabuses were recommended, a short one for all Engineers and a longer one to cater for Engineers who would go into research and development. The main components of the recommended short syllabus were:

1. Algebra and Analysis.
2. Mathematics for Computation.
3. Probability and Statistics.

Some teaching methods were also recommended. The emphases were on:

1. Understanding the mathematical needs of the Engineers.
2. Better collaboration between the Engineering departments and the Mathematics departments.
3. Increasing the motivation of students to learn Mathematics by teaching Mathematics with applications-based examples and Engineering tutorial problems.
4. Increasing the appreciation of the relationship between Numerical and Analytical methods.

The OECD report was regarded by many Mathematics educators as an important landmark in the Mathematics Education of Engineers and was subsequently used as a comparison to review further progress in this area.

"In identifying the role of Mathematics within engineering education the OECD report clearly saw Mathematics as being more than simply a calculation tool. Rather, it was seen as providing the means of investigating the nature of things and providing the engineer with a systematic and logical way of formulating and solving problems in Engineering."

(Bajpai & James, 1985)

There was hardly any dissension among Mathematicians and Engineers on the importance of Mathematics in Engineering Education.

"Today, Mathematics has turned into something more than a calculation tool, it has become a powerful and flexible method of penetrating into the nature of things, particularly those which are dealt with in the fields of science, engineering and industry."

(Gnedenko & Khalil, 1979)

"There are, however, no grounds for dispute on the importance of Mathematics in engineering education.'"

(Scanlan, 1985)

There was, however, some debate and discussion on how the Mathematics should be taught and what Mathematics should be included in the curriculum. There were general criticisms on the Mathematics Education of the Engineers. Then, Mathematics was taught in separate sections of Analytical techniques, Numerical Methods/Analysis and Statistical Methods (Bajpai, 1985). In the OECD Report, the teaching methods recommended seemed to pave the way for the introduction of teaching methods that would enhance the understanding of Mathematics (*vide infra* Section 2.1). Some of the Mathematics educators felt that there should be a greater appreciation of the concepts and techniques involved in using Mathematics to solve Engineering problems.

"..attempting to teach mathematical techniques without an understanding of the Mathematics involved deserves the strongest possible condemnation..."

(Flegg, 1974)

There were suggestions towards rigourous mathematical training of the Engineers but which should be relevant to their needs. These needs were defined as:

(1) the attainment of numeracy,
(2) the ability to follow a mathematical argument,
(3) the ability to formulate a physical problem in mathematical terms and to interpret a solution,
(4) the ability to generate a mathematical argument, and,
(5) development of skills in self education (Scott, 1972).

Other Mathematicians and Engineers have worded their suggestions slightly differently but the list of objectives stated by Scott appeared to embody most of the issues raised in the debate on the needs of the Engineers in Mathematics. There were suggestions that it was necessary for theoretical Mathematical Education to be combined with training in Applied Mathematics, to prepare future Engineers (Gnedenko & Khalil, 1979). There was great anticipation that the development in Computer Technology and its increased use in the Engineering industry would enabled the Engineers to concentrate on research and development in technology (Bajpai & James, 1985). There seemed to be a general consensus among the contributors to the discussion in consistently suggesting that Mathematical Modelling should be an integral part of the future Engineers' Mathematics curriculum.

> *"The course which such students need is not a course in mathematical techniques, nor a course in selected mathematical topics alone, but an integrated course in mathematical modelling."*
>
> (Flegg, 1974)
>
> *"The lecture course should be geared towards the idea of a mathematical model and its solutions."*
>
> (Bajpai, Mustoe & Walker, 1975)
>
> *"Mathematics cannot be taught in a stereotyped and theoretical way, it must have relevance to applied engineering and modelling of problems."*
>
> (Andrie, 1985)

It appears that there was wide agreement that Mathematics was and still is an important part of the Engineering Education curriculum.

Following the publication of the OECD Report, the Council of Engineering Institutions and the Joint Mathematical Council of the United Kingdom set up a Committee on Mathematics in Engineering. On behalf of this committee, Bajpai & Francis (1970) carried out a survey of "Mathematics in Engineering Degree Courses in the United Kingdom". Questionnaires were sent out to Engineering and Mathematics departments of universities, polytechnics and technical colleges. In their analysis they gave no indication of the number of institutions sampled and the number of replies received. There was no detailed breakdown of the number of universities, polytechnics and technical colleges who did reply to the survey. The questionnaire consisted of very long questions asking for detailed information on:

1. (a) the mathematical courses provided by the various institutions;
   (b) how the Mathematical Studies were examined;
2. changes that had occurred in the syllabuses;
3. (a) the situation in relation to the teaching of Computation, Numerical Analysis, Statistics and Probability. The syllabuses referred to were from the OECD Report (pp.65-66, 88);
   (b) opinions on the suggestion made by the OECD Report (p.66) that insufficient weight has been given to Analogue Computing;
4. syllabuses and suggestion on course designs that would allow students some choice to emphasise the operations side of an Engineering discipline. This particular question was very long and put forward two suggestions simultaneously which had to be answered;
5. (a) special teaching methods using closed-circuit television, films, programmed texts and other audio-visual aids,
   (b) remedial teaching for students entering first year without GCE A level passes in Mathematics.

The survey was aimed at finding out the differences between the implementation of Mathematics as recommended by the OECD Report

and the practice of the United Kingdom institutions sampled. Frequent comparisons were made in the analysis with the OECD Report. The authors had analysed their results based on the contact hours of the different courses in Mathematics: Analytical, Computation, and Statistics and Probability. There were some difficulties in making direct comparisons as there were many options offerred by some of the institutions, some courses being of 3 or 4 years' duration. Further complications arose if the Mathematics courses were integrated implying no division between the different mathematical components.

However, the results they produced showed that all the institutions spent less time overall on Mathematics than that recommended by the OECD Report. The chart reproduced from the survey gives the 'Comparison of Total Hours of Mathematics' (Table 1).

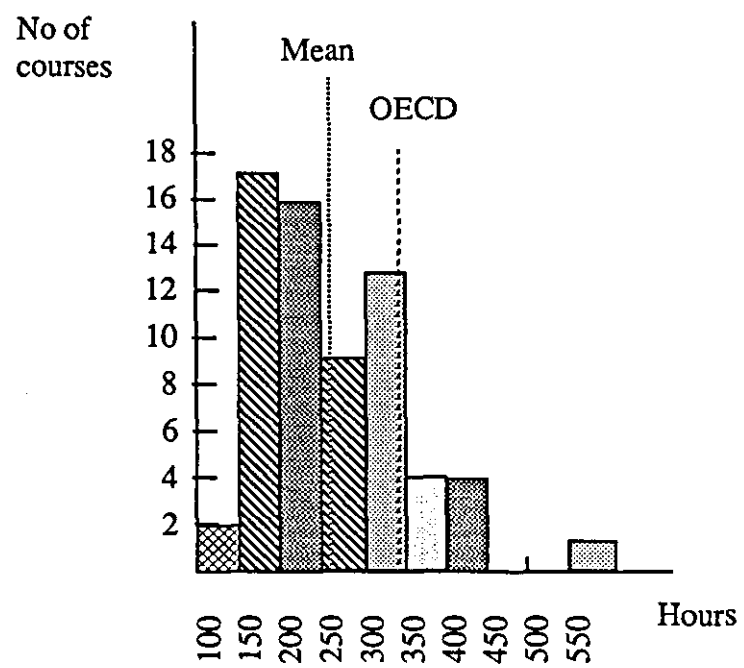
It was also stated that several universities had indicated that they operated an intake policy that required successful entrants to have obtained certain minimum grades in GCE A level Mathematics. Again there was no indication of the types and the number of universities that had this policy. For these universities they had no need to organise any form of remedial teaching in Mathematics. Many other universities said that they provided some form of remedial support in Mathematics for students with poor GCE A level grades or with ONC/OND (Ordinary National Certificate/Diploma) qualifications. These usually took the form of extra tutorials, short intensive pre-sessional courses or in very few cases, such students had to take a preliminary course. The exact number of such universities was not given.

The ONC/OND qualifications referred to here were prior to the setting up of TEC (Technician Education Council) and BEC (Business Education Council) courses. TEC and BEC were set up on the recommendation of the Haslegrave Committee Report on Technician Courses and Examinations. TEC courses were operational in 1976 and the first students graduated from the Certificate Course in 1978 (Times Educational Supplement, 29/9/1978). However in 1983, TEC and BEC were merged to form BTEC (Business and Technician Education

Table 1 : Compulsory mathematical Studies

Mean hours of mathematics	- 260 hours
Number of Courses	- 66
with coefficient of variation of 33 per cent.	
OECD recommendation	-345 hours (133 per cent of mean)

Hours of maths	No of courses
100-149	2
150-199	17
200-249	16
250-299	9
300-349	13
350-399	4
400-449	1
>450	1



Council). It was established by the Government in January 1983 and took over from BEC and TEC in October 1983 (BTEC, 1984). The BTEC certificates are also called ONC/OND and HNC/HND.

The main Mathematics qualifications for entry to an Engineering degree course in British universities were the GCE A level with a minority of students coming into the courses with ONC/OND or HNC/HND (Higher National Certificate/Diploma) and other qualifications in the period before 1978. Scottish qualifications will be considered as comparably close to GCE A level standard. Table 2 gives an indication of the percentage of students with ONC/OND and HNC/HND entry qualfications. The total percentage of students with non-GCE A level and non-Scottish qualifications is also given. The figures were taken from the UCCA (Universities Central Council on Admissions) Statistical Supplement covering the years 1970-1979 inclusive. The information was based only for universities in the United Kingdom and applications made through UCCA. The 'Statistics of Education' publications (now called University Statistics) which would have given figures for all British Universities did not have any information available on non-GCE A level qualified entrants for this period.

However, recently there has been an increase in the number of non-GCE A level qualified entrants in Engineering degree courses. In the years 1988-90, a significant number of candidates entered universities or polytechnics with non-GCE A level and non-Scottish qualifications. A large number of these students had BTEC ONC/OND or HNC/HND qualifications. The SCOTVEC (Scottish Vocational Education Council) qualifications are considered similar to BTEC qualifications.

Tables 3 and 4 gives a comparison of the number of candidates with qualifications other than GCE A level and Scottish qualifications compared to the total number of entrants into Engineering degree courses. The main entrance qualifications were still the GCE A levels. Two sources were quoted to give a clearer picture of the development namely from (i) UCCA Statistical Supplement (Table 3) and (ii) University Statistics (published by the Universities Statistical Record on behalf of the University Grants Committee; Table 4).

Table 2

EXAMINATION QUALIFICATIONS & SUBJECT OF ACCEPTANCE: ACCEPTED HOME CANDIDATES (UCCA, from Table G1)

Figures for ENGINEERING & TECHNOLOGY:
Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, other subjects.

SAMPLE YEAR	TOTAL STUDENT	ONC/OND HNC/HND	OTHER	% ONC/D HNC/D	% OTHER, ONC/D & HNC/D
1970/71	844	75	17	8.9	10.9
1971/72		No figures available			
1973	740	80	14	10.8	12.7
1974	751	66	12	8.8	10.4
1975	816	75	18	9.2	11.4
1976	876	81	18	9.3	11.3
1977	958	90	19	9.4	11.4
1978	975	106	27	10.9	13.6
1979	1050	107	23	10.2	12.4

Table 3

Examinations QUALIFICATIONS & SUBJECT OF ACCEPTANCE: ACCEPTED HOME CANDIDATES (UCCA, from Table G1)

Figures for ENGINEERING & TECHNOLOGY:
General Engineering, Civil Engineering, Mechanical Engineering, Aeronautical Enginering, Electrical Engineering, Electronic Engineering, Production Engineering, Chemical Engineering, Minerals Technology and other Engineering & Technology.

SAMPLE YEAR	TOTAL	BTEC/ SCOTVEC	OTHER	% BTEC/ SCOTVEC	% OTHER, BTEC/ SCOTVEC
1986/87	9608	1190	148	12.4	13.9
1987/88	9466	1165	252	12.3	15
1988/89	10399	1300	360	12.5	16

Table 4

QUALIFICATIONS HELD BY FULL-TIME UK DOMICILED UNDERGRADUATE NEW ENTRANTS (GREAT BRITAIN, University Statistics, from Table 9)

Figures for ENGINEERING & TECHNOLOGY: courses defined similarly to UCCA.

SAMPLE YEAR	TOTAL CANDIDATES	ONC/D HNC/D	OTHER	% ONC/D HNC/D	% OTHER, ONC/D & HNC/D
1986/87	9004	998	644	11.1	18.5
1987/88	8972	1057	752	11.8	20.2
1988/89	8998	1067	764	11.9	20.3
1989/90	9714	1169	902	12	21.3

Although the figures from the two sources are not the same, it serves as an indication of the increase in the number of students entering universities with non-GCE A level and Sottish qualifications. Within this grouping, students with BTEC qualifications are the largest number. The difference in the numbers quoted by the University Statistics and UCCA could be attributed to the inclusion of the SCOTVEC qualified entrants in the UCCA table (Table 3).

This thesis will focus on the mathematical learning of BTEC students in their Engineering degree courses in one particular University which had implemented a special provision (*vide infra* Section 2.2.2) for their BTEC entrants. Prior to the researcher's entry into the research field, she conducted various interviews with lecturers from nearby Colleges which offered BTEC courses in an attempt to understand the implementation of these courses and how the Certificates/Diplomas were awarded. She also interviewed three Admissions Tutor, of the Manufacturing and Civil Engineering departments and of the Electro-Mechanical Power Engineering course in the Electrical and Electronics Engineering department of the University under study. This was undertaken to find out the intake process and policy of the University. The Senior Assistant Registrar of the University was also interviewed. Interviews were also conducted with the lecturers who were responsible for the provision and the lecturer who would be responsible for the Mathematics teaching to the BTEC entrants. Early analysis showed a widespread acceptance among these respondents that Mathematics in BTEC courses did not measure up to GCE A level. Interviews conducted with the students from the BTEC group during the research also indicated that the majority of the student respondents themselves believed that BTEC Mathematics is of a lower standard as compared to GCE A level Mathematics.

BTEC courses were designed primarily for work-related education. They were also designed for people to develop their potential within employment. This is made possible by the availability of programmes of study which are full-time, part-time, day release, block release or evenings only. One of the aims of these courses was to:

"promote the provision of education and training for employees and potential employees which meets the changing needs of industry, commerce and the public services, and which provides students with intellectual challenge."

(BTEC, 1984)

However BTEC National Certificates and Diplomas are becoming an increasingly popular alternative route to university entrance. BTEC qualifications are recognised by the CVCP (Conference of Vice-Chancellors and Principals) and SCUE (Standing Conference on University Entrance) as standard routes to University entrance (UCCA, 1989/90). This was a general ruling on the qualifications for entry. Candidates have to achieve the standard of qualifications required if they wish to enter specialised courses. In all the British universities, the standard is the GCE A level qualifications. BTEC has designed a Mathematics package with the collaboration of the Engineering Council, the Council for National Academic Awards (CNAA) and the Standing Conference on University Entrance (SCUE) which was to provide extra tuition in Mathematics for entry to some degree courses. There was no indication in BTEC literature why such a package was thought to be neccesary though a brief mention was included in the UCCA handbook on 'Examinations and Grades: Notes for University Selectors 1989/90' that some Admissions tutors were concerned about the suitability of BTEC Mathematics to some degree courses with special reference to Engineering. The unit titled "Mathematics" was intended to develop further the mathematical competence of BTEC candidates who wished to pursue Higher Education in Engineering courses. It was designated at level NIII with a unit value of 2 and should be part of the normal Mathematics course. The syllabus contents correspond to the Mathematics module in the Engineering Council's "Standard and Routes to Registration" (SARTOR) document (BTEC, 1986).

Ten years after the OECD Report was published, some Mathematics educators expressed concern at the lack of progress made by some British Universities in achieving the Report's objectives (Bajpai & James, 1985). There was a call for the importance of Mathematics within the Engineering curriculum to be more fully recognised by

both the validating bodies and professional organisations. However, there were other interesting developments on the cooperation of the Engineers and Mathematicians in their efforts to better the teaching of Mathematics in the Engineering curriculum (*vide infra* Section 2.1) which will be discussed in a later part of this section.

2.1 Literature survey on research into the mathematical deficiencies of Engineering undergraduates

The mathematical deficiencies and learning difficulties of Engineering undergraduates in UK universities and polytechnics have been well documented (Cornelius & Marsh, 1977; Heard, 1978; Smith, 1979; Morgan, 1988) and is not specially related only to students with the earlier ONC/OND and later the BTEC ONC/OND qualifications. Some researchers however have found that a larger proportion of students with these qualifications had difficulties with their Mathematics in the first year of an Engineering degree course.

> *"The O/HNC/D students include a disproportionately large number of low performers in M1, E1, M2, E2, especially in Mathematics."*
>
> (Heard, 1978)

A brief summary of the literature surveyed in this area will follow and brief descriptions of some of the measures that have been undertaken by various institutions around the world in dealing with the learning difficulties of Engineering undergraduates in Mathematics will also be given.

Researchers into the mathematical learning difficulties of the Engineering undergraduate have not been able to ascertain the root of the problems. They have, however been able to identify specific mathematical topics that have given students much difficulty. Consequently, various programmes have been designed and implemented to remedy the situation.

Rees (1973) looked at the mathematical learning difficulties among Craft and Technician students. She found that certain mathematical topics gave the students great difficulties. She claimed that the main reasons for these difficulties were: lack of understanding of concepts, lack of knowledge and understanding of formulae. Her work has encouraged other researchers to look into the same problems at the undergraduate level (Gonzalez-Leon, 1979; Smith, 1979; Morgan, 1988; Rees, 1989).

Bajpai, Mustoe & Walker (1975) highlighted some shortcomings in the teaching of Mathematics to Engineers and suggested some improvements. Their improved Mathematics syllabuses and guidelines to its teaching seemed to have embodied most of the recommendations of the OECD Report (*vide supra* Section 2.0). They also came up with a new philosophy for the teaching of Engineering Mathematics. These authors had implemented this philosophy in the course they were teaching. Their work was carried out at Loughborough University where the current study has also been undertaken. A more detailed look at their work is warranted in order to study the curriculum development of Mathematics for the Engineers which has also resulted in the current provision of a separate course in first year Mathematics for the BTEC students (*vide infra* Section 2.2).

Gonzalez-Leon (1979) undertook a scheme of work which was aimed at diagnosing and providing remedial support in Mathematics for first year Engineering students at Southampton University. The study was first conducted in 1976 for Civil Engineering students and was extended to all Engineering students in 1977. The article reviewed did not contain the specific details of his work. No figure as to the number of students and staff involved in the scheme was given. He had also distributed questionnaires to the students to evaluate the scheme and to find out the students' previous knowledge in Mathematics linking these to their entrance qualifications but did not include a sample of the questionnaire in the article.

The first scheme in 1976 was carried out in the first two days upon entrance but this period was extended to one week in 1977. In the first Mathematics lecture, explanations were given to the students

about the scheme. They then had to take a specially designed multiple-choice diagnostic test which would be marked by a tutor immediately. The students were seen one at a time and given advice or suitable materials for revision on the topics which they had answered incorrectly. These materials were in the form of programmed texts, specially written notes and selected books.

In his analysis, Gonzalez-Leon referred to analysing the scripts of a post-test but no details were given. However, in his conclusions, he identified certain topics found difficult by more than 25% of the students. These were: Binomial Expansion, Trigonometry, Inequalities, Logarithms, Exponentials and Integral Calculus. He also gave probable reasons for these difficulties which were that the students had forgotten their work and made careless mistakes.

He further analysed the pre-knowledge test results in terms of entrance qualifications (double Mathematics or single Mathematics at GCE A levels, ONC/OND or HNC/HND) and syllabus content (Traditional Mathematics, SMP Mathematics or combined methods). He concluded that students with GCE A level in Mathematics performed better than students with ONC/OND or HNC/HND. However, he did admit that some students were unable to give correct information about their previous syllabus content. He had recorded the comments of some of the students to show that the revision work was found useful. If his findings could be considered as providing a realistic picture of the students' difficulties in the topics mentioned, it would be difficult to accept that these students would find subsequent work in Mathematics easier just by attending the revision scheme. Unfortunately there is no mention of any follow-up programmes.

At Plymouth Polytechnic, Smith (1979) conducted a research to identify the mathematical deficiencies of the first-year students in Engineering courses. A scheme implemented as remedial support for these students was also described and evaluated. Her research aims and methods were influenced by the study conducted by Rees (1973) among Craft and Technician students and later among teacher trainees (Smith & Howarth, 1980).

The research sample was the Engineering students' intake of 1978. A diagnostic test on mathematical competence was developed which was taken by 98 students out of a total sample of 115. This was carried out during the Freshers' Induction week. There were 30 questions in a multiple-choice format that focused on:

(1)	basic knowledge	definitions, formulae and theorems
(2)	number theory	size and order
(3)	algebraic manipulation	applying the rules of algebra to rearrange and simplify expressions
(4)	modelling	describing a given situation in mathematical symbols
(5)	general competence	interpreting information and selecting a method of solution for a new problem

For each of the questions they defined:
Facility or F value = % of correct responses and
W value = % of wrong responses.

In the analysis of the test questions, common areas of weakness were identified. These were Inequalities, Algebraic Manipulations, translation of descriptive problems into mathematical symbols. In her discussion with the staff responsible for the teaching of Mathematics, she concluded that there were also other Mathematics topics in which the students were found lacking such as Conic Sections, Curve Sketching, Factorisation and Completing the Squares of Quadratic Equations and the theory of Logarithms. In most of the Mathematics topics mentioned, there were some agreement between her findings and those of Gonzalez-Leon (1979) discussed in the preceding section.

A scheme involving a self-paced instructional remedial course was designed to overcome the problem. It was called a Levelling-Up (LU) course. The course was run in parallel to the normal undergraduate studies. Students who had achieved marks of less than 50% in the competence test were advised to take the LU course. Some of the materials used were taken from a similar course which was

established at Brighton Polytechnic and others were specially written for the course.

A student had to work on his own but could attend an hour weekly tutorial if he had any problems. If he had mastered the unit, he would be given a short test which would be marked immediately by a tutor. To pass, the student had to answer every question correctly, otherwise further reading or exercises were set for him. There were some problems encountered in the running of the course which were due to the heavy demand on staff time and the large workload on the students as the course was an addition to their normal prescribed course of study. A minority of the students could finish the LU course in the first term with the rest finishing the course halfway through the second term. A second competence test was administered to evaluate the success of the course. A comparison of the students marks was given but restricted to those students who had partcipated in all assessments including the end of session examination. Table 5 is reproduced from Smith & Howarth (1980) and gives the 'Average student performance in assessments (per cent)'.

Table 5

AVERAGE STUDENT PERFORMANCE IN ASSESSMENTS (PER CENT)

Student Group	Number of students	Pre - U course test score	Post - LU course test score	End of session exam marks
Group A: regular LU course attenders	37	36	57	48
Group B : Non-Attenders who achieved >50% in pre-LU course test	29	66	65	64
Group C: course defaulters including those who rejected advice to attend	6	35	38	41

It is not easy to draw any conclusions on her results as there were many factors that could have influenced students performance in the tests and examinations. Among these were: (1) the three Engineering courses set different examination papers; (2) the heavy workload of the students who took the LU course; (3) some students were lagging behind their colleagues in the main Mathematics class because of their participation in the LU course; (4) students' attitudes and beliefs about Mathematics and towards the LU course. In the article. they did not claim any strong causal relationship between the LU course and students' performance but only concluded that there was indication that the course could have conributed to improve performance. However, in her thesis, Smith concluded differently in that there was no significant indication that the LU course helped the students in Group A with their examination performance (*vide supra* Table 5).

She did obtain some informal students feedback through conversations and found that students regarded the LU course as separate to their main Mathematics course. She also reported that the students needed time to get used to a course without lectures and that there were requests for some lectures. Staff did not put on any lectures as they felt the students were motivated enough to work on their own. She also found that students with ONC/OND were the most worried about their Mathematics upon entrance and welcomed the course as a chance to improve their Mathematics.

It does appear that in both the studies, by Gonzalez-Leon and Smith, similar techniques of research were implemented. The main research findings seemed to be the identification of Mathematics topics that gave students difficulties and to proceed with helping the students to improve their understanding of these topics. It appears that these topics were considered important for the students to master in order to help with their main Mathematics course. Students with ONC/OND were consistently identified as weaker in Mathematics. In Smith's thesis they were also identified as the most worried about their mathematical abilities. Details were sketchy in Gonzalez-Leon's paper that it is difficult to appreciate and form a complete picture of his work. Smith & Howarth were more thorough in the description and

analysis of their study though there does appear to be a slight discrepancy in the conclusions of the article and her thesis on the value of the LU course.

Clark and Shannon (1980) were also concerned with proposing a solution to the difficulties of teaching first year Mathematics. They identified the varying levels of achievements, abilities and entrance qualifications of the students in Mathematics as the source of the problem. A modular approach to the degree course was considered a possible solution to the situation. In this approach several modules would be offered on Mathematics and students could choose the number of modules required based on their abilities and their course requirements. Among the modules would be an Introductory Mathematics module.

Such a module was implemented at Oxford Polytechnic. It was evaluated by the students through a questionnaire. The questionnaire was given to all first year students who took the course and to higher year students who had previously taken the course. For the first year students, in addtion to the questionnaire, two forms of semantic differential were designed to evaluate their attitudes towards Mathematics and the ways of learning Mathematics. They defined semantic differential as:

> *"..essentially a combination of controlled association and scaling procedures which seek to measure the common cultural core of meaning in a concept such as 'Mathematics'"*
>
> (Clark & Shannon, 1980)

The analysis of the study by Clark & Shannon provided some interesting results on students attitudes towards Mathematics. It appeared that:

(1) though the students did not consider Mathematics pleasant to study, they found it valuable;
(2) they preferred the personal attention in the problem classes more than the lectures;
(3) students who were less able mathematically were more keen to

master the basic skills in Mathematics.

The effectiveness of the questionnaire in evaluation depends heavily on its construction. In this case, the authors claimed that they had put much preparation into the choice of questions by conducting a prior analysis of the aims and expectations of staff and students. The study was aimed at finding out how effective was the modularization of the course in helping this particular institution cope with a wide range of students entrance qualifications and abilities.

Barrett, James and Steele (1979/80) conducted a study aiming at discovering the level of mathematical skills and ability of undergraduates at the end of their first year. Questionnaires were sent out to 40 British Universities and 30 Polytechnics excluding Scottish Institutions. They received responses from 31 Universities and 21 Polytechnics. They stated that the GCE A level and the ONC/OND were the two most common routes of entry into British universities. They commented that students with ONC/OND were regarded to be weaker in Mathematics and claimed that their research findings supported this assumption. They said that institutions which took entrants with lower grades (D & E passes) in their GCE A level and those with OND/ONC have had to provide extra work or tuition for these students. They were supposedly lacking in basic manipulative skills.

It was apparent that surveys utilising questionnaires were one of the more popular research techniques used. It could be that with such a method a large number of respondents from the student body or the Higher Education institutions could be sampled and thus the subsequent results could be generalised. In the above study, there was no indication why the ONC/OND students were considered weaker than their GCE A level colleagues from the start of the research though this assumption was considered justified by the authors after analysing their questionnaires. Students with grades D and E were also considered in need of remedial support.

However in a study by Heard (1978), it was shown that more students were coming into the Engineering degree course with one GCE A level

qualification in Mathematics as compared to having double Mathematics qualifications. He claimed that it cannot be assumed that students with this single qualification in Mathematics had a strong mathematical background. Again, there were comments that the varying contents of the syllabuses followed by students at school or colleges were such that it was difficult to determine what previous knowledge in Mathematics can be relied on upon entry on the degree courses.

Heard conducted a survey of 49 Engineering departments from 18 universities with the students sampled totalling 4834. The universities were visited for at least two days where he met members of staff for discussion. He then distributed the questionnaires to the students with opening explanations and waited for them to fill the questionnaires. He answered any queries. Some observation of first year Mathematics teaching was included and details concerning the organisation, syllabuses and work sheets were taken. A detailed analysis was undertaken on these various areas:
(1) entrance qualifications; (2) women students; (3) mathematical background; (4) break between school and university; (5) mathematical difficulties at university and (6) university examination performance.

It is difficult to comment on all aspects of his analysis but in his conclusions Heard pointed out that students with ONC/OND and HNC/HND were at a disadvantage because of their weakness in Mathematics. He also suggested that universities should send to prospective students a statement of mathematical prerequisites but warned that such prerequisites should not be too ambitious. There also should be better communication between Engineering and Mathematics departments to meet the needs of the Engineering undergraduates.

Godfrey (1985) described a common first year Mathematics programme carried out for the Engineering students in Warwick University which used non-traditional teaching methods. 'Traditional methods' referred to the usual lectures and tutorials. The programme had a strong remedial content to accommodate students coming in with various qualifications especially mature students who would have left school

or college quite a long time before coming to the University. They implemented a scheme of programmed learning for their Mathematics course.

Their programmed learning of Mathematics was designed to satisfy two requirements namely, the remediation and the relevance of the Mathematics to Engineering. The format of the course incorporated a 50 minute lecture session per week with handouts that described topics to be covered during the week, assignments to be tried, any supplementary notes and examples. There was an hour weekly small group tutorial session which normally consisted of two or three students. Other members of the Engineering Department also participated in these tutorials by supervising some groups. Quizzes which consisted of short multiple-choice questions or past examination questions were handed out to be completed by the students working (open book) on their own. These assignments were handed to their tutors in the following tutorial and were not credited to the final assessment. They were found to be useful as remedial work and revision. The Mathematics course was assessed by a three-hour examination at the end of the academic session.

The scheme conducted by Godfrey was similar to that proposed by Bajpai, Mustoe & Walker (1975/76). These were attempts to improve the methods of teaching Mathematics giving greater consideration to the relevance of Mathematics to Engineering problems.

The Scottish Universities Council on Entrance had also conducted a study which showed that there existed a large variation in preparedness for University Mathematics even within groups of students with similar backgrounds. In his paper Searl (1985) discusses the various approaches to teaching Mathematics at Edinburgh University. He claimed that the students of Engineering found Mathematics difficult, boring and had problems of motivation as they felt that Mathematics was not relevant to their course. He had also identified some areas of weaknesses which were : Index laws, Algebraic manipulation, Finite Geometric Series, properties of Logarithms, Inequalities and Trigonometry. He suggested that these

fundamental difficulties were the results of the students' failure to grasp basic techniques as well material poorly consolidated at school.

Searl was concerned with rectifying the prevalent situation by improving the teaching strategies of the lecturer. He believed that the aim of learning at university was ultimately to train the students to be independent learners. As such the teaching approaches should be geared to achieving this aim. There should be a stronger emphasis on small-group learning situations. Tutorial classes could be more fully utilised to provide oppurtunities for (1) more personal contact between the students and their lecturers; (2) get students' feedback on the lectures and their learning; (3) solve any problems related to their Mathematics course. He also recommended the use of learning support materials such as tapes with guided booklets and television to supplement teaching. There should also be provision for individualised student managed materials.

As with the other articles or reports reviewed in the preceding sections, there was concern at the students' apparent lack of mathematical abilities upon entrance at the University. The similar stand taken by the various institutions was to implement courses and teaching methods to enhance the students' Mathematics learning at the universities. There was some comments suggesting that the problems were also the result of the students' mathematical learning at schools. However there does not appear to be any reference to research conducted on the learning of Mathematics at schools to support their assumptions. There is also no indication of cooperation between the different bodies involved in the education processes such as schools, colleges, polytechnics and universities in trying to find the solutions to the students' difficulties in Mathematics. There should be some concern about the situation as it appears that the same difficulties are reported to be present among the students at different universities.

There have been certain developments in the collaboration of different institutions and the people concerned with Engineering Education. Among more recent efforts were a series of conferences, 'European Seminars on Mathematics in Engineering Education'

organised by SEFI (European Society for Engineering Education) which held its first conference in March 1984. Since then they have held yearly conferences dealing with various aspects of Mathematics Education for the Engineering undergraduates.

Such conferences have illustrated the widespread concern not only in UK but in other European countries as well. From a paper presented by Kurz (1985), from the Fachhochschule fur Technik in Germany, a study of various remedial courses offered by Institutions of Higher Education in the Federal Republic of Germany was described. Several terms were used to describe such courses and these were: bridging courses, supporting courses, refresher courses, pre-study courses, pre-first semester courses and repetition courses. They were usually supplementary, optional and non-creditable courses. He made the following conclusions:

(i) students lacked simple manipulative skills in basic Mathematics;
(ii) students had varying entrance qualifications and abilities in Mathematics;
(iii) there existed a pronounced lack of knowledge in certain topics in simple Algebra and pre-Calculus for some students. These topics were similar to those described by Gonzalez-Leon (1979) and Smith (1979);
(iv) there existed diffferences between the expectations of institutions of higher learning and the actual proficiency and skills of students upon entrance;
(v) the secondary system offered varieties in their syllabuses all yielding qualifications to post-secondary education but the tertiary system in a given field started from uniform requirements.

Kurz also made some recommendations as follows:

(i) prospective students should be told of the standard of Mathematics required in his chosen field.
(ii) standards required should be based on the syllabuses offered to the students at their respective schools.
(iii) the foundation studies should take into account the actual

Mathematics that the students have upon entrance based upon knowing the Mathematics syllabus they have followed at schools. The topics taught in the foundation course should be matched to the needs of the specific fields of study that the student will follow at the university.

(iv) small group teaching was preferable.

(v) some degree of individual-based support in the remedial courses should be introduced. There should be combined efforts in teaching and counselling students who need the remedial course most.

(vi) courses should be designed and offered in a way to motivate students' participation.

Other efforts in cooperation were also established. The Committee of the Teaching of Science of the International Council of Scientific Unions (ICSU-CTS) and the International Commission on Mathematical Instruction (ICMI) had organised symposia concerned with the teaching of Mathematics as another major subject in a non-Mathematics course. Proceedings of the symposia were published as part of a Study Series for ICMI. In the third of these series, various papers from all over the world dealing with the teaching of Mathematics also highlighted similar problems facing other university educators.

Clements (1988) described an innovative method that he had carried out in Bristol University to teach Mathematics. Even though, it was not primarily concerned with the mathematical deficiencies of students, it was concerned in ensuring that students who were taught Mathematics could retain that knowledge and be able to apply it where necessary. He was concerned with the development of students' confidence in their ability to read mathematical books and learn Mathematics independently. He also wanted to introduce flexibility in the depth that students study the materials to take into account their various previous knowledge and current needs. He wanted to generate students motivation and encourage discussion among themselves.

His teaching methods were based on three approaches:

(1) guided reading - this meant that the lecturer would prepare a set of commentary notes which would detail the exact extent of the section to be studied from the text books. Commentaries on the ideas presented in the book would also be given, some additional worked examples and recommendations on which exercise to be attempted by the students.

(2) simulation/case studies - consisting of a series of exercises which were given to the students. The aim of the exercises or simulation/case studies was to give the students some experience in using Mathematics to solve real industrial and commercial problems. Relevant material would be given to the students. The problem would be stated in terms of the problem domain and not in mathematical terms. The students had to understand the problem and determine what sort of Mathematics would be needed to solve it. They would usually worked in small groups. During this session, staff would play the role of project leader in an advisory capacity. Each exercise would be of two to three weeks' duration. Suitable problems were requested from industry. The actual problems used were usually based on these with changes made as determined by the donor.

(3) continuous system simulation laboratory - the term simulation here is used differently from (2) above. The term here is used for the description of the material and the techniques being taught. He used a simulation package, BCSSP (Bristol Continuous System Simulation Package), which was specifically written for the course at Bristol University. The objective of the laboratory was to give students the necessary training in working with systems they were relatively unfamiliar with. They had to integrate simulations and the application of their theoretical analytical skills in order to understand the properties of the systems they were dealing with.

The course was already implemented for eight years at Bristol when Clements reported on it. The teaching method required extra demands on the staff especially in the amount of contact time needed. A firm commitment on the part of the staff to play the different roles described was needed. It also required adequate computer facilities

with adequate informal access time for the students. He mentioned that the projects set required the students to work in between the formal laboratories sessions. He also mentioned some resources difficulties and that the students were still examined at the end of the year with a three-hour written paper.

Murakami (1988), from Kobe University, Japan, conducted a survey to investigate how to improve mathematical Education for Engineers. The survey was based on questions on what Mathematics was to be taught, how the contents of such courses should be taught and who should teach them. The questionnaire were given to the members of staff of the Engineering Faculty at the University where he worked and to staff in the Mathematics Departments which taught the Engineering students in other universities.

He did not specifically write about students' mathematical deficiencies but claimed that students do not generally enjoy Mathematics nor do they appreciate its usefulness to their chosen area of study. They usually found it difficult to catch up on all the mathematical topics being taught. Murakami did not provide any evidence for his comments on the students' dispositions nor did he give much information about the survey as his paper was concentrated on its analysis. He had provided a list of mathematical topics to be considered by his respondents. Unfortunately, the list was not included. He reported that:

(1) most of his respondents agreed that Calculus, Transformations and Linear Algebra were important and essential. Opinions on the other topics were more varied.

(2) Both Mathematicians and Engineers seemed to agree that emphases should be on the acquisition of skills and knowledge in topics such as Calculus, Complex Variables, Fourier Analysis, Differential Equations, Vector Analysis, Numerical Analysis, Probability and Statistics. No discussion on the teaching techniques was given except for a brief comment that all suitable methods should be employed.

(3) All the Engineering staff agreed that Mathematics should

be taught by the Mathematicians. Though some Mathematicians thought that some areas of Applied Mathematics would be better taught by Engineers.

Siegel (1988), from the Towson State University, Towson, Maryland, USA mentioned that most American colleges and universities offered remedial Mathematics as a first Mathematics course. Research conducted in the USA had revealed that lecturers felt that their students lack conceptual mastery of Mathematics and could not apply what they had learned. From the article, it appears that conceptual mastery referred to the ability of the students to understand mathematical concepts which was then linked to the ability of these students to choose methods of solution to new problems or to to use the Mathematics in their own specific fields of study. He discussed the importance of developing students' abilities in (1) communicating Mathematics verbally and in writing; (2) doing the Mathematics; (3) learning to relate to Mathematics and (4) learning to learn Mathematics. He felt that these considerations would help students understand and appreciate the Mathematics in their course.

In Australia, there were also projects being carried out by some of the Institutions of Higher Education to alleviate the lack of Mathematics in new entrants. Blyth and Calegari (1986) carried out a programme of multi-level entry recruitment based on entrance grades or voluntary assignment of groupings to cope with the diversity of students mathematical skills. This was implemented at the Royal Melbourne Institute of Technology, Melbourne. Students coming into this Institution usually had HSC (High School Certficate) or the alternative TOP (Technical School Certificate) Mathematics qualifications. Students were recruited and streamed into three sequential levels: level 1: remedial group, level 2: ordinary stream, and level 3: advanced placement. The students were streamed based on their entrance qualifications in Mathematics and their performance in the diagnostic tests administered upon entry. Changing from one level to the other was possible with consultation with the lecturers responsible for the teaching of the different courses.

The remedial component was semi-self-paced. Students were allowed to control their studying as they had to work on their own from a textbook but the lecturer determined the pace by some boardwork and the timing of the tests. Students were frequently tested on the topics learnt and in some cases repeat tests or extra assignments were given. 80% mastery was required before progress was allowed through the materials. The textbook was the main teaching material as students preferred it over other materials because of its portability. Remedial students were required to take an extra semester to complete their course. They strongly believed that the lack of Mathematics in their students coming in with non-traditional Mathematics could not be achieved through short remedial courses.

Hubbard (1986) described the setting up of a Remedial Mathematics Facility at the Queensland Institute of Technology, Brisbane. The students entering this Institution came from various educational background. They had students who came directly after school or those who had some years' gap between school and Higher Education either due to being in employment or those who had other reasons for the gap. The students had to take a multiple-choice test on Mathematics upon entrance. The test scores were only used as a general guide to the students' mathematical abilities and knowledge. Students who did not score well would be advised to attend the Remedial Facility.

The Remedial Mathematics Facility (RMF) was a place to help students overcome their mathematical deficiencies. Self-learning modules were provided and tutors were at hand to provide assistance. The remediation was held concurrently with their first year courses. She found that tutors at the centre were also assisting in problems faced by students in their regular course. She claimed that the integration of remedial and tutorial assistance was successful in encouraging the students to use the facility. Attendance was voluntary though some students were advised to attend based on the entrance test taken during the first week of term.

The researchers from both these Australian Institutions claimed that their approaches were successful in providing the solution to

overcoming the mathematical deficiencies of their students. The articles that were reviewed did not give specific details on the entrance tests conducted and the questions that were given. We could assume the standard of Mathematics required for entry to Engineering degree course would be similar to the GCE A levels as these authors also referred to studies conducted in the United Kingdom. However, there are differences in the methods used in the Royal Melbourne Institute of Technology in that students weaker in Mathematics were taught separately. No indication was given if they were taught separately in their Engineering subjects. In Queensland Institute of Technology, there was remedial work as well as an on-going support for students who needed help in their Mathematics at the RMF.

Morgan (1988) investigated the problem of the lack of mathematical expertise of Polytechnic Engineering degree students and the relevance of these problems to the structure of mathematical abilities. He did his research, based in Brunel University, England, following in the footsteps of Rees and Furneaux (1976). He also conducted diagnostic tests on his student sample. The questions for the tests were specifically designed to differentiate between the mechanical and thinking processes in doing Mathematics. He hypothesised that two main factors existed in the structure of mathematical ability namely:

(1) 'g' factor which referred to the general intellectual ability. 'g' type questions were structured problems which could be solved provided some standard programme of instructions has been learned.

(2) 'I' factor which referred to the special mathematical factor. I type questions would require an ability to conceptualise the problem in such a way that the relevant operations can first be identified and then applied in proper combination and sequence.

He conducted his research on first year Engineering degree students with ONC/OND, HNC/HND and GCE A level entrance qualifications. He also sampled second and third year students. In his conclusions he found that there was no difference in abilities between first, second

and third year students. There was some indication that students with GCE A level Mathematics did better than those with BTEC qualifications. However performance in GCE A levels could not be used to predict subsequent performance at degree level.

He suggested various measures to identify students' difficulties and teaching strategies to improve the students' performance. Among these were suggestions for more personal contact with students and private consultations to identify difficulties. More effort should be made to know students' past experiences in his learning. Students should be taught learning strategies. Other suggestions were directed at the lecturers to incorporate more discussions and explanations of wrong responses. Integrated teaching with correct sequencing of topics should be implemented. More difficult topics should be given more teaching time. There was still a need for remedial courses which should promote conceptual understanding. He also called for reforms to be carried out in pre-University mathematical teaching and curriculum although he did not specify the exact changes that were required.

Clements (1985) felt that there should be changes in the Mathematics curriculum in Engineering Education. This should follow from the recognition of the major role played by computers and computational methods in the Engineering Industry. He suggested that the Mathematics curriculum should emphasised the need to develop in the undergraduate engineer an appreciation of the overall properties of particular classes of mathematical tools and an understanding of more general concepts rather than the detailed knowledge of a small number of specific formulae. His teaching methods has been reviewed in the preceding sections.

Simons (1988, 1990) also argued for a change in the contents of the service teaching of Mathematics. He claimed that the availibility of mathematical software has allowed most problems to be solved easily. He strongly emphasised that the computer should only be used as tool. Students should be taught the mathematical concepts involved in the techniques of solving problems. They also needed to understand the concepts in order to use the software effectively. The use of the

computers would allow more time for exploration and experimentation with complex problems.

Hubbard (1990) criticised lecture courses in Mathematics citing the reasons below for changes to be considered:

(1) students were coming into university with extremely variable knowledge and experience;

(2) it was difficult to determine a suitable pace for the development of the highly sequential materials;

(3) students often faced difficulties in taking notes whilst remaining attentive to the lectures and incorrect copying was detrimental to understanding of the notes and.

(4) it was difficult to ensure effective learning in a large classroom.

She proposed a scheme of teaching Mathematics incorporating programmed texts which meant the students were responsible for their learning. Contact was maintained through tutorials, discussion groups or student presentations.

Conclusion

In the preceding sections various areas concerned with the teaching of Mathematics especially to students considered weak in Mathematics have been reviewed. In the various studies, specially designed courses or systems were suggested and implemented to cope with the problems that were identified. Some studies had been based on research and others were based on the experiences of the lecturers concerned in the teaching of Mathematics. Some of the conclusions and findings of the studies were similar and replicated (Gonzalez-Leon, 1979; Smith, 1979). Morgan (1988) in particular took a more traditional approach based on the experimental psychology school in directing his study at the factors influencing mathematical ability. Taken in total, there appears to be a wealth of schemes which have been implemented and evaluated in addressing the problems of the lack of the mathematical abilities of new entrants to Engineering degree courses.

There also seemed to be world wide concern about the mathematical abilities of Engineering undergraduates upon entrance into a university. In the UK, some researchers and lecturers had identified that a larger proportion of students coming in with ONC/OND and more recently with the BTEC ONC/OND and BTEC HNC/HND, would faced difficulties in Mathematics. There were claims that the advantage of GCE A level qualified students was only in Mathematics and no significant differences existed in the students' performance in Engineering subjects (Heard, 1978).

In general, there were certain common situations that affected all the entrants regardless of their entry qualifications. These were:

(1) the students followed a wide range of syllabuses at school/college,
(2) the students had different mathematical abilities,
(3) there was a long break between school/college and entering the University especially for those who had been working, this meant that quite a lot of their school\college work has been forgotten.

These situations created problems for the University lecturers in that it was not easy to assume what was the common ground that the students could start off from. There was always someone who would be repeating a topic or someone who had not heard it before. The different mathematical abilities of the students also implied that each student had different needs.

There appeared to have been some common teaching strategies being implemented and recommended. There was more concern with establishing personal contact with students. Small group interaction either in the teaching class or tutorial groups with more emphasis on discussions were suggested consistently. Innovative approaches in teaching which had utilise and encourage self-learning strategies among the students were tried and strongly recommended. Some researchers have made efforts to follow other research developments but the lack of reference to any qualitative research studies was very noticeable. All the research and studies reviewed were

conducted using similar approaches based on the scientific methodology in Educational research.

2.2 Curriculum developments at Loughborough University of Technology

2.2.1 Background

This section will present the developments of Mathematics teaching to Engineering undergraduates at Loughborough University of Technology as documented by the members of staff in various documents (articles, reports, theses). No attempt has been made by the researcher to evaluate their appraisal of the developments. Her research would be concerned with a curriculum innovation, the 'BTEC' Mathematics course, and its implementation.

The OECD Report 'Mathematical Education for Engineers' (*vide supra* Section 2.0) recommended a core curriculum in Mathematics in Engineering Education. Following the report, the Council of Engineering Institutions and the Joint Mathematical Council of the United Kingdom set up a Committee on Mathematics in Engineering. The committee requested Professor A.C. Bajpai and D.C. Francis to carry out a survey on Mathematics in Engineering Degree courses in the United Kingdom (*vide supra* Section 2.0). In the analysis of the survey, frequent comparisons were made with the OECD report. It could be seen that the OECD report was made an important corner stone to activate research into the Mathematical Education of Engineers.

The Loughborough University of Technology was established in 1966 with a Royal Charter. It had progressed from being the Lougborough Technical Institute through various periods of expansion and change (vide Appendix 1).

The teaching of Mathematics to Engineering and Science students was the responsibility of the staff of the Department of Mathematics. Owing to the development of new courses in the University, a review

of the Mathematics syllabuses was undertaken which resulted in the formation of a common core syllabus that emphasised the applicability and relevance of the Mathematics taught. In the interest of the Mathematical Education of technologists, the Mathematics Department consulted other departments in the University and other educational establishments. There was a need for research into Mathematical Education and this resulted in the formation of CAMET (Centre for the Advancement of Mathematical Education in Technology) which was established in 1966 under the direction of Professor A.C. Bajpai. The Centre was part of the Department of Mathematics.

The members of staff at CAMET and the Department of Mathematics were actively involved in such research and proceeded to put into practice the recommendations of the OECD Report as well as formulating new recommendations towards the teaching of Mathematics. The Centre also organised conferences, short courses and seminars on Mathematical Education.

Professor Bajpai was well known for his opinions on the need for a new approach in the teaching of Mathematics by integrating the Analytical and Numerical Methods. His views were presented at many conferences, seminars and papers that he wrote with his colleagues (Bajpai et al, 1970; Bajpai & Francis, 1970; Bajpai et al, 1975/76; Bajpai, 1985; Bajpai & James, 1985)

A brief description of the developments in Mathematical Education at Loughborough given chronologically as far as possible will follow as much of the work on curriculum developments were conducted under the auspices of CAMET.

In 1970, Bajpai, Calus and Simpson wrote a paper entitled "An approach to the teaching of Ordinary Differential Equations". The paper described the approach formulated by Prof. Bajpai. He felt that in order to proceed he had to show his method in practice. In that year the "International Journal of Mathematical Education in Science and Technology" was also founded under the editorship of Professor Bajpai, Professor W.J. Martin (Chairman of the Faculty, Department of Mathematics, Massachusetts Institute of Technology) and Dr. D. Walker

(CAMET). The journal provided a medium to present a wide range of experience in Mathematical Education. It signified the commitment of CAMET to further research in Mathematical Education.

Ten years after the publication of the OECD report, Bajpai, Mustoe and Walker (1975,1976) produced a lengthy paper in two parts to review the progress being made in the Mathematical Education of Engineers and made suggestions of developments required. They had also developed a new philosophy in the teaching of Engineering Mathematics and described its implementations in a new course that they taught. They wanted the student to find the Mathematics course stimulating, relevant and useful.

This course had been developed during the five years prior to the publication of the paper. The main emphases of their new philosophy were:

(1) motivating students by introducing mathematical models to illustrate the relevance of the techniques that they were learning.

(2) Each major department should be taught by a specialist Engineering Mathematics lecturer.

(3) The Mathematics taught should be relevant to its Engineering contexts. The use of realistic problems as case studies would be adopted.

(4) An integrated approach would be adopted in which the Analytical, Numerical and Statistical techniques were taught on a problem-solving basis.

(5) A balanced approach between a 'cook-book' approach and rigour would be adopted. They criticised textbooks which only taught Mathematics by presenting specific formulae to solve specific problems and provided exercises which were variations of the worked examples. In particular, they thought students should be taught to select the suitable mathematical techniques for any given problem. On the other hand, they did not want the course to be as rigourous as for the Mathematicians.

(6) Syllabuses would be reviewed regularly to take into consideration developments in Engineering.

(7) Increased liasion between the Mathematics Department and the Engineering Departments that were serviced.

(8) Lecture groups will consist of students from one Engineering Department so that the ordering of topics and the model examples can be fitted to the discipline concerned.

(9) Remedial work would be organised for weak students to ensure uniformity in students' abilities.

(10) Teaching approaches would be varied and computer-aided learning would be implemented. The students would be able to communicate with the computers in learning mathematical processes. They would be able to make their own decisions and test their consequences.

They had developed a course that is based on their new philosophy and the outline of the course is as follows:

1) Two courses were run in parallel for the first year students. The first group comprises students from the departments of Civil Engineering, Chemical Engineering and students following the course of Environmental Engineering. The second group were students following courses in Mechanical Engineering, Transport Technology and Production Engineering. This second group consisted of students whose courses commenced in January. The first group were included because their departments wanted to participate in the new course. During this period there were two intakes for the University which were in October and January.

2) The course was taught by two lecturers from the Mathematics Department.

3) The first year course occupied 4 lecture hours/week for the first term of 10 weeks (1 hour of which is devoted to providing remedial lectures for ONC qualified and other entrants), 3 hours/week for the second 10-week term and 3 hours/week for 6 weeks in the third term.

The students were also divided into groups of 20 or less usually from one department for tutorial/problem class of an hour's duration each week. The lecturers participated in these

sessions so that at least one group from each department would be supervised by one of the lecturers.

4) Contact between the Mathematics lecturers and parent Departments was maintained formally as well as informally.

5) Two approaches were tried for the course in Computer Programming. (i) The Civil, Environmental and Chemical Engineering students attended a 3-days 'crash course' in Fortran IV programming. The course consisted of a series of lectures and problem classes. Several problems were set which required the students to write and run their programs and these were handed in for assessments after 1 month.
(ii) The other students had two out of four lectures each week for the Fortran course. This was because of time-tabling difficulties.

6) The integrated approach was implemented in the teaching of Mathematics which meant that any Analytical, Statistical, Numerical and Computer techniques which were relevant to a particular topic were discussed or mentioned when the topic was taught. A first year textbook, "Engineering Mathematics" (Bajpai, Mustoe & Walker, 1974) was developed by the authors based on this teaching approach.

7) A simple project was set in the second term which required some background reading, carrying out some Algebra, Analysis and then writing and running a computer program to complete the problem.

8) The main assessment was a three hours written examination at the end of the year.

9) Frequent references were made to mathematical models and students were encouraged to be critical of the models that they encountered.

10) The level of competency expected of student was that they would be able to solve problems. The techniques learnt were applied to standard and non-standard questions. Worked examples were given in the lectures and further examples was set for the tutorials.

In 1974, the Department of Mathematics was divided into three departments: Mathematics, Engineering Mathematics and Computer

Studies. CAMET shared joint schemes of teacher education with the Department of Education and the Department of Computer Studies. The service teaching of Mathematics to Engineering students was conducted by the staff of the Engineering Mathematics Department.

Up to 1984, the students with ONC/OND qualifications were taught Mathematics in a separate course as they were identified as having more difficulties in Mathematics. They would have covered the same topics in Mathematics as the A-level students but in less depth as they would have had less time for it.

The students were taken in two separate intakes, one in January and the other in October. The main course started in January. The students who came in October used to work at the Centre of Industrial Studies. They were at the centre on Monday, Tuesday and Wednesday. Mathematics and Science were taught on Thursdays and Fridays. The Mathematics course was designed such that it would be more intensive and helped to bridge the gap between the course they had done and preparing them for their part 1 course in January.

CAMET was also involved in other projects involving Mathematics Education, expanding the research interest from the Mathematics Education of undergraduate Engineers to teacher education. In 1979, the All India Mathematics Education at CAMET (AIMEC) Project was started and this was a significant development in the research undertaken at CAMET into in-service teacher education. Under this Project 23 teachers from schools and colleges in India were seconded each year to work at the Centre. This continued until 1985.

In 1983 the Microcomputers in Mathematics Education (MIME) Project was started at CAMET to promote Computer Enhanced Learning. Micro-based software for Mechanics, GCE A Level Applied Mathematics and Physics and Statistics were produced. These were specifically designed to help mathematics at the school/university interface level. It was in this year that Mrs. A came to work for the Department. She became involved with the MIME Project at the distribution and evaluation stage. As she is a principal figure in the research, further details would be discussed in Chapter 4.

About this time (1983/1984), the Engineering Departments changed their intake procedures and all students began their course in October. This meant that the ONC/OND students came in with the main group. BTEC ONC/OND and HNC/HND became the main alternative qualifications from this period as it had effectively replaced the TEC and BEC courses. In an interview, Mrs. A described the changes and commented that:

(Extracts of interview, Mrs. A, 14/6/90)

> *"....these people came in the main stream....the main group and that we just started with the main course and picked up the casualties as we went along....."*

Dr. B then organised an extra hour of lectures per week in the first ten terms. Topics were selected from the GCE A level syllabus which were thought to be necessary but not covered in the first year Mathematics course. Notice was given in advance as to what topics would be taught so the students could decide if they wanted to attend the lectures. Attendance was on a voluntary basis. These lectures were mainly for the Civil Engineering students but students from the Mechanical Engineering Department also attended. Mrs. A felt that this measure was not satisfactory,

(Extracts of interview, Mrs. A, 14/6/90)

> *'because it's rather like plugging the gap after they stumbled (laughs), I'm mixing metaphors a....you know to learn about trig identities at the point when you should be using trig identities is not very helpful. It would be better if you knew something about it before you began and it's better if people don't fail and then had to learn through failure. I mean everybody learns through failure at some point but a... it's better I think if you ..if there wasn't such a gap between what they've done before and what they're expected to....'*

In 1985, software units that covered topics in first and second year Engineering Mathematics were produced. They were developed by Bajpai and Mustoe with the help of one of the programmers from the MIME Project. The first unit was on Complex Transformations which

had five programs: Simple Transformations, Inversion, Joukowski Transformations, Streamlines and Schwartz-Christoffel Transformations. The software was written in two versions:

(i) A user interface using the keyboard and
(ii) A user interface using five keys only. Input was made via (a) the cursor control keys including the Return key or (b) a joystick connected to the analogue input socket or (c) a specially designed five-keys pad connected to the user port.

Nine further units were produced with the first eight under the authorship of Mustoe: Poles and Residues, Numerical Solution of Linear Equation, Numerical Integration, Numerical Solution of non-Linear Equations, Cubic Splines, Numerical Solution of Ordinary Differential Equations, The Water Tank, Fourier Series and ANOVA (Analysis of Variance). The units were used to enhance lectures, in tutorials, and was also available in self-paced modes for students.

Further contributions to the revolutionised teaching approach were made when a series of programmed learning textbooks that were used as support materials for the courses were written.

Mustoe (1988) wrote a thesis which described in greater detail the development of the strategies in teaching Mathematics to Engineering undergraduates. He was deeply involved in the production, evaluation and implementation of the teaching strategies and its underlying philosophy.

In August 1988, the Departments of Mathematics and Engineering Mathematics was merged to form the present Department of Mathematical Sciences. Professor Bajpai retired and CAMET was dissolved. The service teaching of Mathematics is still being carried out by the staff of the new department.

2.2.2 The Present

The philosophy that was introduced in the 1970's has now become the ethos of teaching Mathematics to the Engineering undergraduates. All the lecturers who are currently teaching the subject have been teaching students in the parent Engineering Department for at least 10 years and some were involved in the development of the philosophy at its inception which means that their experiences go further back.

In an interview, Dr. B, who was a key figure in setting up the separate Mathematics course for the non-GCE A level qualified entrants, identified the demographic decline of eligible students and the small number of Engineering graduates who actually pursue a career in Engineering after graduation as reasons to increase the number of students intake. He also concluded that,

(Extracts from interview, Dr. B, 26/6/90)

> *"So therefore it must mean that in order to keep numbers on the courses at the required level we shall have to recruit students whose abilities has been lower than that to which we have been accustomed and particularly since the selection is in most cases based heavily on their Mathematics ability then we have to take on board people whose Mathematics is of a lower standard."*

The same ideas were presented at a recent conference where Dr. Mustoe discussed the changing demands of teaching Mathematics to Engineers in the future (Mustoe, 1990).

At Loughborough University of Technology, a proposal was considered and has been approved to establish a Foundation Year. It was aimed at widening access to Science and Engineering degree courses and to complement the traditional entry into these courses. It hoped to attract applicants who would not normally be considered suitable for entry into Science and Engineering courses. These would include students with good GCE A levels in non-science subjects and mature students who would be considering to take up degree courses

through Access courses. Access courses are alternative entry routes into Higher Education opportunities for mature students in specified subjects with collaboration between Adult, Further and Higher Education Institutions (Osborne & Woodrow, 1989). The Foundation Course will be considered as a preliminary year for undergraduate degree courses in the Schools of Engineering and Pure and Applied Sciences. Students will have to achieve a satisfactory standard in the course before starting on the three year course proper. The Course would be introduced in October 1991.

Presently, three recognised routes of entry to Higher Education has been specified by the DES (Department of Education & Science). These are the Sixth Form qualifications, the vocational qualifications and the Access courses (DES, 1987). As such, students with BTEC qualifications would not be taking the Foundation Course.

The University is also changing to a quasi-modular based system for all courses, to take effect from October 1991. The Mathematics syllabus would then be developed into several modules. Its implication for the Mathematical Education for Engineering students with BTEC qualifications would be that they would be required to take an extra module.

Against this background of past developments, future planning of changes and the fact that students who do not have good GCE A level Mathematics are considered and have been identified as those who would have difficulties in Mathematics, the current provision was implemented in October 1990. With this provision, Engineering undergraduates coming in with BTEC qualifications would be taught Mathematics separately. It was to be more intensive with extra time allocated, small group teaching and possibly using learning support materials such as computer packages. The aims were that (1) at the end of the year they would be more able to cope with the University style of teaching Mathematics and (2) come up to the standard required to continue with Mathematics in the second year. They will rejoin their colleagues in the second year and will then be taught Mathematics within their respective Departments. In all other subjects, the students are taught within their Departments.

In providing this separate Mathematics course, a principle was compromised in the teaching of Mathematics at Loughborough University (*vide supra* Section 2.2). Dr. B described it as *"It's history repeating itself.."*

CHAPTER 3

RESEARCH METHODOLOGY AND PERSPECTIVE

3.0 Introduction

The studies and research into Mathematical Education of Engineers at undergraduate level which were reviewed (*vide supra* Section 2.1) suggested that they were based on similar methods of investigation which were in effect, variants of the 'scientific method' (Cohen & Manion, 1989). They were mainly concerned with establishing 'cause and effect' in 'teaching and learning'. Thus the initial aims were to identify students' difficulties and the factors or processes which would affect the Mathematical Education of the students. Attempts would be made to establish the relationships between the relevant factors and variables. An experiment would be designed with a systematic and controlled manipulation of the variables to see if the expected results would be produced. Thus, correlation would be 'scientifically' shown to move into causality.

Suitable treatments would be consequently designed and implemented in an attempt to improve teaching and to achieve better learning outcomes in Mathematics. These would be in the form of specially designed courses, provision of learning support materials (textbooks, notes, audio-visual materials, etc), students' support (counselling, learning centres, small group teaching, personalised help) and the use of learning aids (computers, video, films and slides). The normal indicator of students' abilities and understanding were their performance in a written examination at the end of the course. In some institutions, some form of course work was also used as assessment in conjunction with examinations (Clements, 1983; Mustoe, 1988).

Usually, and particularly in England and Wales, these programmes, though subscribing to 'scientific methods', were not overtly 'scientific experiments'. Research utilising a rather more rigid scientific format appeared more popular in the United States of America, where many programmes attempted to compare the effects of different teaching methods on learning. This research format would usually be in the

form of a group being taught with the teaching method under study, for example, Slavin's "Cooperative Learning" Model (Valentino, 1988), Gagné-Briggs Model for instructional design (Goldberg, 1986) and a control group who would be taught with the customary method. The choice of students in the group would be matched as much as possible on their abilities, academic and social background, though in some cases, no such effort was made. A series of tests would be conducted at the beginning, middle and the end of the teaching period. The test scores would be analysed statistically. The results would be compared to show if there were significance differences between treatments (Valentino, 1988; McCollen, 1988; Grove, 1987; Sullivan, 1987). Commenting on this general methodological trend, in connection with research into mathematical learning, Chapman (1972) observed that,

> *"Unfortunately this influential American preoccupation with experimental respectability limited the kind of work undertaken; rats are easier to control in an experimental situation. Hence Tolman's cry, "Rats not men".*

There have been research programmes which have adopted less traditional formats but which would still be closely identified with the 'scientific methods'. These were the work of Wertheimer (1961) and Polya (1981) in which learners would be asked to solve problems and to record their thought processes. Recent research programmes, had reflected the same strategies in which diagnostic tests were used to select adult learners for subsequent interviews in an attempt to find out how they had thought out problems (Rees, 1973; Morgan, 1988, Goldberg, 1986). Some of these sessions were recorded on tape. These research programmes, although committed to the 'scientific method' appear to have incorporated other research techniques more familiar within qualitative research methods.

There have been other researchers in Mathematical Education who have been more openly committed to qualitative research methods (Bishop, 1985; Bishop & Nickson, 1983; Oaks, 1987). They would include constructivists, who were interested in what teachers and students actually did in the classrooms and how they thought, as well as

researchers concerned with the social context of Mathematics. The qualitative research perspective has produced considerable conflicts and debates leading to discussion on different methodologies.

In general, however, there appears to be a trend moving towards more dialogue and cooperation among educational researchers who use different qualitative methods (Bogdan & Biklen, 1982); although, in research on Mathematical Learning at undergraduate level, a lack of communication between researchers using the different methodologies still seems to be apparent. This is a reflection on the general research situation in Mathematical Education (Eisenhart, 1988).

There is a need for greater cooperation as many research designs especially those concerned with open-ended questions such as student achievements, students' and teachers' beliefs and attitudes could be better investigated using a variety of methods found in qualitative research.

3.1 Qualitative Perspectives and Methods in Educational Research

The researcher strongly felt that the 'scientific method' would be inappropriate for the students and the scheme under study. The aims of her research were to follow the curriculum development of the provision, looking at the factors that would influence its progress and implementation, how the aims set at the beginning of the course translated in reality and what were the students perspectives in response to the provision. As such, a qualitative perspective has been adopted and the reasons for utilising qualitative research methods were made on the following basis.

1. The factors or variables affecting the students' learning would be non-controllable.

   The 'scientific' or 'positivistic' perspective would not account for *'man's unique ability to interpret his experiences and represent them to himself'* (Cohen & Manion, 1989). Research on attitudes towards Mathematics and beliefs about Mathematics or

some of its topics (Bassarear, 1986; Holder & Wankowski, 1980; Bell, Costello & Kuchemann, 1983); teacher expectations, self-perception, motivation and personality and how these would influenced students' achievements and their learning outcomes (Gopal Rao, 1968; Blease, 1983; Oaks, 1987) has shown that students would not be passive participants within their learning environment.

In subscribing to the 'scientific method', some degree of simplification, restriction and controlling of variables would have to occur. The learning process would thus be simplified and a direct relationship between the treatments prescribed and the learning outcomes would be assumed. Such manipulation of variables would project a synthetic and restricted learning environment. The results of the experiment would only offer a segmented description of the class under study or would only highlight how the carefully selected factors and variables would influenced the learning process.

In a situation where there would be many interacting variables, the best possible way to study the learning process would be to observe the learning sessions in progress. A descriptive account would allow the inclusion of as many variables as possible and potray their interactions (Merriam, 1988).

2. The learning situations would be 'time-embedded' and not replicable.

The scheme under study would possibly be a unique undertaking. At the beginning of the course, it was not clear, if it would be a continuing provision as other changes to the undergraduate courses were also planned (*vide supra* Section 2.2).

It would also be difficult to replicate the learning situation under study as it would not be possible to assemble students with exactly the same personalities, backgrounds, entrance

qualifications and all the other factors that would have had an effect on the situation.

3. A case study rather than studying samples.

Choosing samples to study would inevitably forced certain criteria of selection to be used thus indirectly requiring the identification and labelling of the factors and variables affecting mathematical learning for this particular research. To avoid this limiting condition, the researcher chose to study the whole group of students within the special Mathematics provision as a case study. The focus of this research is on the students coming in with BTEC qualifications and how these students cope with the Mathematics taught at undergraduate level.

Kenny and Grotelueschen (1980) has offered several reasons for choosing a case study design for research. One reason was

> *"to develop a better understanding of the dynamics of a program. When it is important to be responsive, to convey a holistic and dynamically rich account of an educational program, case study is a tailor-made approach"*

Defining case study research appeared to be more difficult. Case study has been variously defined as "*an instance drawn from a class*" (Adelman, Jenkins & Kemmis, 1983); "*the examination of an instance in action*" (MacDonald & Walker, 1977); "*to reveal the properties of the class to which the instance being studied belongs*" (Guba & Lincoln, 1981); and Becker's (1968) twofold definition: "*to arrive at a comprehensive understanding of the groups under study*" and "*to develop general theoretical statements about regularities in social structure and process*".

The term itself is subjected to various confusing associations which were criticised by other qualitative research

practitioners (Shipman, 1981; Atkinson & Delamont, 1986). Some researchers have considered it to be a research design separate from other qualitative research methods (Stenhouse, 1982; Walker, 1986). Some considered case study research as a design within which any suitable research methods, qualitative or quantitative, could be implemented (Cohen & Manion, 1989). The choice of techniques would be dependent on the research problems and the objectives of the research. Thus it would be possible to carry out an ethnographic case study, a historical case study (Merriam, 1988) or a case study which produced data which could be quantified (Adams & Biddle, 1970).

The researcher has adopted a case study research design as it was thought to be most suitable for studying the provision for the BTEC qualified students. A variety of methods has been used which recognised the qualitative and subjective nature of its data. In order to determine the areas of significance, to check the reliability and consistency of data, a long term study would be conducted (Walker, 1986).

Qualitative Research is used here as an umbrella terminology to describe several research strategies sharing similar attributes. It is associated with other terms which include ethnography, field research, field work, interpretive research, case study, phenomenological and symbolic interactionism. (Burgess. 1984; Bogdan & Biklen, 1982).

Researches that have been using these strategies were invariably based on two main traditions of sociology and anthropology (Delamont & Atkinson, 1980). The underlying concern in the studies of schools and classrooms was in the sociocultural process of schooling, development of theories of culture and social relations (Hargreaves, 1967; Lacey, 1970; Woods, 1979; Ball, 1981; Burgess, 1983).

A qualitative research programme is usually a study of the research situation in context. Qualitative researchers do not necessarily approach research with specific hypotheses but allow these and theory to emerge from data. The research design and structure is

flexible, responsive to the setting and uses progressive focusing. This means that as data collection builds up, the researchers will develop a focus for the research. Great importance is put on understanding the participants or research subjects views and perspectives. In order to allow for perturbation or reaction to the researcher's presence in the natural setting, considerable time is spent within the research setting. Any interaction within the subjects is kept as natural as possible, unobtrusive and non-threatening. By recording data observed as well as data given by the participants, the researcher could determine the effects of his presence. In relating any accounts, particular attention would be given to the nature and context of the events reported thus enabling a more objective understanding of the incidents.

3.2 Research Design Decisions

In this research, suitable strategies from various types of qualitative research have been used. The research aims are towards identifying students' difficulties and the factors that would influence their Mathematical learning. This research is an intensive study of students' feedback. It looks at the reality of the implementation of one particular course in Mathematics for a group of undergraduates identified as having a weak Mathematics background. It serves to enhance the understanding and appreciation of a Mathematics class in action, day by day. It does not seek to be in conflict with other studies conducted by other research methodology but to enhance judgement and appreciation.

In designing the research programme, the following decisions were made.

(1) The data will be taken from the natural setting and the researcher will be the research instrument.

The researcher would enter and spend considerable time with the group under study to understand the context in which learning would have taken place as well as the perspectives of

the group members. One definition of such a situation identified as field research is,

> *"... a learning situation in which the researchers have to understand their own actions and activities as well as those of the people they are studying."*
>
> (Burgess, 1982a)

The researcher would have to consider how the descriptions, analyses and criticisms of the settings will be mutually interdependent on the conditions occasioning them (Cohen & Manion, 1989). Such a notion has been termed **reflexivity.** She should be concerned with her own subjectivity and its effects on the data. In this style of research, she should blank out her own ideology and try to interpret the situation in the same way as the participants. To enable such an interpretation to occur, the researcher should constantly confront her opinions and prejudices. By spending a considerable amount of time in the research setting, employing various means of collecting data and the gradual building up of data, it would be possible to develop an insider's view but with an outsider's objectivity (Burgess, 1982b).

(2) The research will be concerned with the participants' perspectives.

The researcher should be motivated by the desire to know (Woods, 1984) what the students feel about their Mathematics learning and the views of the lecturers who designed the course and the lecturer who teach it. How would the students respond to being identified as a group of mathematically deficient students? How would they negotiate the meaning of a university student? How does the lecturer translate into daily actions and interaction her analysis of the students' difficulties and how they should be helped? What would be the influences on her teaching plans and strategies?

The researcher should be aware that her presence could be affecting the situation under study. The participants would be attempting to manage their impressions of her and her research during the early stages of the research. She should be sensitive to any **reactivity** and should take measures to minimise and identify these in relating her accounts. Accounts that will be related in context would help in some way to rectify these incidences. The development of a closer relationship between her and the participants would also minimise these effects.

(3) **The process of data analysis would be inductive**

The researcher would not be entering the field with pre-determined hypotheses seeking data to prove or disprove them. However she would know the research problem that she wished to study but could not be certain as to what would be discovered, what or whom she would concentrate on. She would construct her hypotheses and theory from the data accumulated.

Some analysis of the data will also be done simultaneously with data collection. It is a characteristic of such research that the design and direction of the research could be suited to the emerging theory. As the data grows, the researcher would be able to focus on the theory.

In organising the data, she should use the notion of **indexicality.** Indexicality is defined as,

> *"...the ways in which actions and statements are related to the social contexts producing them".*
>
> (Cohen & Manion, 1989).

3.3 The Research Implementation

In October 1990, the Engineering students coming with BTEC entrance qualifications into the Civil Engineering Department, Mechanical

Engineering Department and Manufacturing Engineering Department were taken together as a separate group in Mathematics. The aims of the scheme provided for them were (1) to bridge any gaps in their mathematical knowledge and abilities, (2) to prepare them to the level of proficiency required in the second year and (3) to allow more time for the students to get used to the university style of teaching. Just before the course started, students with similar qualifications from the Electrical Engineering Department were also brought into the scheme. Figure 1 gives a detailed breakdown of the different departments and courses feeding students into the provision. Mrs. A was chosen to teach the class due to her experience in teaching Engineering students as well as her background as a secondary school teacher before joining the University.

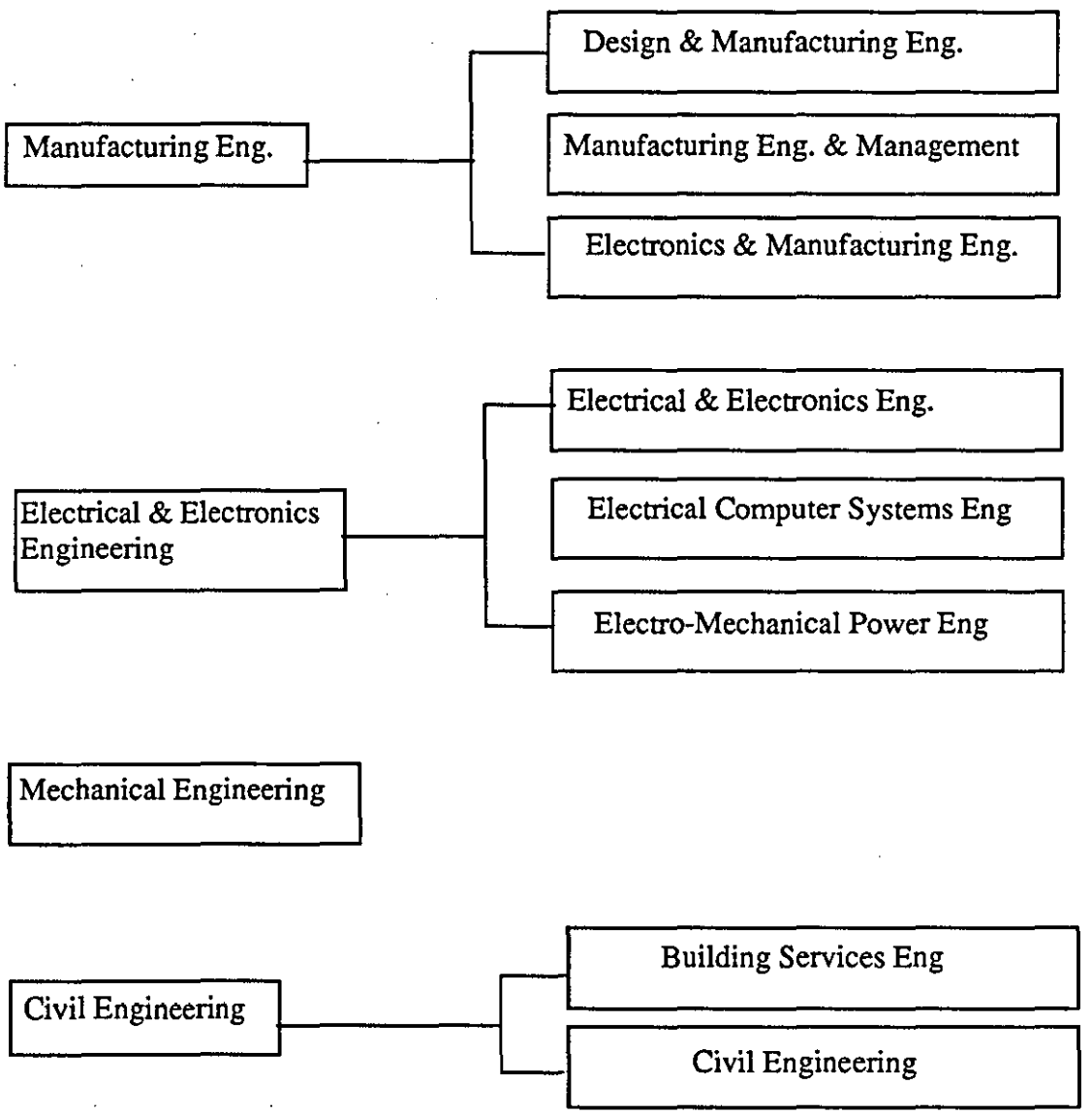
The researcher has joined in all the Mathematics lectures and tutorial sessions for the whole academic year. This totalled to 25 weeks where the course ran for 10 weeks in the first (Autumn) term, 10 weeks in the second (Spring) term and 5 weeks in the third (Summer) term. An early research decision was to allow hypotheses to 'emerge' from the data, although the author did not intend to follow other researchers, such as Glaser & Strauss (1967) slavishly to produce 'grounded theory'.

The researcher's earlier experiences in her own teaching environment had given her some ideas and speculations on the difficulties of students learning Mathematics. This meant that to enter the field with no fixed set of hypotheses had to be a conscious decision.

This was easier in theory than in practice but she tried to overcome this problem by being a reflective practitioner. Among the first problems that she faced was the constant desire to compare and relate her present study with her experiences and the problems of her students in Malaysia. A definite action in "letting go" and to temporarily forget the Malaysian problems was necessary in order to fully appreciate the current provision under study. There was a need for the development of greater sensitivity, awareness and understanding of the students and lecturers perspectives. This was done by undertaking the following steps in the nine months prior to

Figure 1

Engineering Departments and courses of students participating in the BTEC special provision for Mathematics



the arrival of the students at Loughborough and the teaching scheme in October.

(1) Conducting a series of pre-field work interviews.
As a novice researcher, it was thought necessary and prudent to test and select some research methods before embarking on the main research programme. To do this, the researcher visited two Further Education Colleges to collect data and background information on the BTEC teaching system, how the certificates/diplomas were awarded and to identify any issues considered relevant by these respondents/informants to studying BTEC students in Universities.

This excursion has enabled the researcher to test various interview techniques and to focus on the main issues of the subsequent research. The experience proved to be valuable as a research training exercise and in addition highlighted a number of important research questions. An account of this initial exercise in research is given in Appendix 2.

(2) Conducting interviews with key lecturers and admissions tutors at Loughborough University. These members of staff would be involved in setting up the Mathematics course and with student admissions to the University. The interviews aimed to identify the extent of any problems in Loughborough, as perceived by them (*vide infra* Chapter 4).

(3) Developing a relationship with the lecturer who will be teaching the course. Contact was first established with a formal introduction. An interview was conducted which was followed by numerous formal and informal discussions. The research relationship established between the author and the lecturer will be presented in Section 4.5.2. The open and easily established relationship between the researcher and the lecturer was a great help in conducting the research. This was a positive reflection on the personality of the lecturer concerned (*vide infra* Chapter 4).

(4) Undertaking a literature search of various studies and research done in this area. It appeared from the literature reviewed, that most research which had been undertaken in this area did not used qualitative research methods (*vide supra* Section 3.0).

3.4 Entering the field

In the process of entering the field, the researcher needed to consider certain issues, which are now listed.

1. Entry

Entry to the research situation was easily negotiated with the lecturers concerned. Dr. B who was the senior lecturer concerned with the setting up of the provision, and Mrs. A, the lecturer who would teach the special group, were most accommodating. They agreed that the researcher would be allowed to follow the class concerned and participate in all their lectures and tutorials. Mrs. A had designed innovative teaching strategies that she would be implementing with the students. She was also intending to conduct a personal research to evaluate the effectiveness of these innovations.

2. Access

The first opportunity to seek access with the students was given in the first Mathematics class of the term. The author was given 10 minutes to introduce herself and describe the research she would be conducting giving an outline of its purpose and methods. She also asked the students for permission to follow them and participate in their lectures and tutorials. She then handed out letters to all the students requesting interviews. It was made clear that their participation was voluntary and would be kept anonymous in any resulting accounts.

3. Ethics

There has been much discussion about the merits and demerits of 'overt' or 'covert' field roles that a researcher assumes. The author is well aware that in some ethnographic studies, though conducted in non-educational settings, covert research was considered necessary. This was especially in research which attempted to expose behaviour hidden from public view (Whyte, 1981; Ball, 1979).

However, the researcher believed that in this particular setting the best way to develop the research was in an open role. She felt strongly that the main purposes of her work were to advance knowledge of undergraduate engineers with non-traditional entry qualifications and to help curriculum designers in order to guide the mathematics teaching and to understand and improve the conditions for Mathematical learning of such students. The researcher decided that, an overt role would match these purposes better than a covert one, since it was hoped that the subjects (lecturers and students) would become willing informants rather than objects to be observed by an outsider.

4. Researcher's Prejudices

The development of the trust and confidence of the participants in the research and the researcher is considered important for the progress of the research (Woods, 1986). Before entering the field, the researcher was besieged by worries that her presence would be difficult to accept as (1) she was not British, (2) she was a Muslim dressed strictly according to its teachings and therefore would stand out, (3) the Salman Rushdie affair might prejudice the views of some of the students towards Muslims and (4) she might fail to grasp and understand the cultural and social fabric of the British students.

Measor (1985) and Delamont (1984) found that the issues of dress and appearance were considered important by the people they were researching. They had to appear in conformity with the different people that they were interviewing and this strategy had helped them to elicit more information and establish a rapport with their informants. The researcher's strong adherence to her religious principles could not allow her to change her dressing. She also felt strongly that she should enter the field as she is. Any form of play acting would be eventually difficult to maintain as she would be participating in the setting for a long period of time. She hoped that by being a reflective practitioner, she would be able to convey in her accounts and analysis any bias or problems encountered. She was not totally without any experience of life in England as she had completed her GCE A levels and undergraduate studies here (1974-1979).

Later during the course of the study she realised that a certain degree of apprehension and pre-conceptions of the research field was not uncommon to ethnographic researchers, especially to novice researchers, as the beginning of work is likened to "*a plunge into the unknown*" (Ball, 1990). She also found out that most of her worries were baseless and that through the year they did not impede her friendship with the students and the lecturer.

3.5 Research Methods

The technique most associated with the qualitative research methods is **participant observation** which would allow the researcher to work with subjects in their natural setting. However, there are other techniques which would complement the observations. These would be through conversations, unstructured (informal) interviews, formal interviews, surveys, questionnaires and by collecting other documents (students' records, diaries etc).

In this research, several of the techniques were adopted. The choice of methods depended on their suitability to any given situation or individual. For example, information solicited during interviews was usually recorded on tape. It was considered that this technique would help to capture the thoughts or views of the informants during that instance. In some incidents, casual conversations after an event would highlight the student's views on site. Conversations and informal discussions with the lecturer concerned would give the same insight to her views on the same particular incident. In this particular situation, it would be difficult to tape the sessions so field notes were used. The researcher then had to choose her methods as and when the occasion arose. Field notes were written as soon as possible after the incident or observation.

The main methods that were used in this research were:

1. Participant Observation

This research study of the mathematical learning of a group of undergraduate Engineering students was conducted by participating in their Mathematics lectures and tutorials only. Gold (1958) discusses four different modes of participant observation which ranges from complete participant, participant-as-observer, observer-as-participant and complete observation. He described the complete participant role as one in which the researcher would become a member of the group under study. It was deemed suitable in situations where the researcher would not wished for the subjects to know that they were being researched. He distinguished between the roles of participant-as-observer and observer-as-participant. In taking the former role, the researcher and the researched would be aware that their relationship stems from the research. The researcher would be participating in the setting because of the research. In the latter role, the role of observer is made public from the start of the research and contact with the participants is brief and formal. The complete observer role would entirely remove the researcher from any interaction with the research subjects.

Other terms are also used to describe the different modes of participant observation. These include 'hard-line' and 'soft-line' approaches (Ball, 1985). Researchers adopting the hard-line stance felt that the researcher had to participate fully and share in the activities of their subjects in a direct way. This conforms to Gold's complete participant mode. While in the soft-line approach, it was only necessary to emphasise,

> *"the necessity of the observer's presence but without specifying the need to do what the researched do."*
>
> (Ball, 1985)

In this study, the participant observation was definitely soft-line and followed Gold's participant-as-observer mode closely. However, the adoption of any particular role would be based on its appropriateness to the situation under study.

The organisation of the Mathematics course was based on programmed learning using a programmed textbook with a series of supporting lectures. Tutorials were in small groups assigned according to departmental groupings. There were some laboratory sessions with packages on the micro-computers. The style of delivery in the lectures was in the traditional sense. The lecturer presented the materials and wrote down the notes usually on a transparency roll for the overhead projector. In such a situation, there was little exchanges between the lecturer and the audience except for the occasional queries from the students or questions from the lecturer. Here, the researcher could only be an observer.

Tutorials were conducted in a less formal atmosphere. Students were encouraged to ask questions, to discuss the mathematical problems or other problems related to learning. The researcher would sometimes be involved in these exchanges. It was easier to participate in these sessions as students were allowed to talk and form discussion groups. Some movement was also allowed in the room.

As mentioned earlier (*vide supra* Section 3.3.2), the researcher was introduced to the class at the beginning of term. There were frequent re-introductions made in the tutorial sessions in the earlier stages of the research. Mrs. A would usually try to include the researcher in conversations and would casually mentioned the reason for her presence. Thus some time was needed, and used, to ensure that all the students knew the researcher and that the class was being researched. At other times, the researcher would also freely give any information pertaining to her work if queried by the students in particular. At this stage there were frequent discussions with the lecturer so that she was well informed of the various stages in the research.

At the start of any interview with students, the researcher would also state the objectives of the research and emphasised that all communications would be treated in confidence. The students were reassured that any materials quoted or used would be anonymous. In adopting this demeanour, she hoped to reduce any anxiety on the part of the students that her work would have some negative effects on them if they decide to collaborate. She also promised to send any relevant documentation to her informants for their validation.

2. Interviews

The interviews were usually unstructured and non-directive. It has also been termed 'informant' interviews (Powney & Watts, 1987). In such interviews, the interviewee has been given some freedom to impose on its structure though an agenda has been loosely set by the researcher. The interviews were conducted in a conversational style so that control could not remain static (Armstrong, 1990). This meant that the researcher did not relinquish all control of the flow of the discussion. She would try to keep the discussion within the set agenda. Later in the year, some of the conversations would stray beyond the agenda. She would usually allow the conversation to take its course and if the tape ran out, she would keep the recorder

off for the rest of the session and revert to written notes. She felt that such a procedure helped and reflected the rapport between herself and some of the students.

During the first day of the course, she had handed out forms requesting the students for interviews. She felt that it was necessary to conduct the interviews while they were still fresh at University and she was still a stranger to them. She thought that this would be helpful as a check on future interviews. It would serve as a guide to gauge the development of the relationship with the students and would indicate if there were any difference in the students' attitudes in being interviewed by a stranger and someone they knew. She could also use these interviews to find out the students' expectations and views on life at University upon entry.

The first set of interviews were conducted only on those who volunteered. Students who said they were willing to be interviewed were given an invitation letter to set the times, venue and dates for the interviews. The researcher's room at the University was also offered as a possible venue.

The researcher then had to be aware of probable bias in her first respondents as she was only interviewing those who volunteered. There could be different reasons for this willingness, namely, they are genuinely interested to help in the research, they were willing to share their views or they had grievances to air. At that stage, as she had not developed any relationship with them, they were strangers to her as she was to them.

The natural development of friendly relationships with some of the early respondents and the opportunity to get to know them better enabled the researcher to reflect on any opinions or information given by them more judiciously. However with other respondents where such opportunities did not arise, observations of their behaviour and comments during lessons, tutorials or laboratory sessions or during casual conversations

were among the steps taken to identify possible influences to any views or opinions volunteered.

The researcher had listed a few themes for discussion as a guide for herself. For the first interview she prepared this list as a guide for the interviewee as well. However, she found that the particular interviewee used the themes as questions and answered linearly down the list. There was little room for discussion. It was a very stilted atmosphere. For the following interviews, she did not give the respondents the list but used it as a guide only for herself. She did tell the interviewees on the themes that she was interested in but invited them to talk about their experience in learning Mathematics freely.

In order to identify any sources of distortion (Whyte, 1984) of the interviewee's descriptive and evaluative data, a second interview was held with the same respondents in the second term. The researcher had managed to get to know them better during the intermittent period as well. Numerous conversations and informal discussions were conducted with these students. She was in a better position to judge the reliability of the opinions expressed by the interviewees.

The interviews were informal but the approach to plan and set the time and place of the interviews were semi-formal. The interviews would be by prior appointments only. The sessions were tape recorded. Most of the students did not seem to mind or took no notice of the tape recorder but there were a few who were uneasy about a permanent record of their views. The researcher stressed before the interview, or during it as necessary, that she would treat the information on the tapes as confidential. She explained that she would not, and could not, influence lecturers or authorities at the University. If their accounts were used, it would be done anonymously and as far as possible, they would be given a copy to check before publication. All the students or other informants (lecturers, admissions tutors) said that they did not mind if they did not receive the copies and were willing to be quoted anonymously

or otherwise. However, the researcher would be using **informant validation** as part of her research strategies. Though there are researchers that would prefer informal interviews to be regarded as conversations or discussions (Woods, 1986), she has decided to differentiate between the two forms of data collection. Even in the most informal interviews, some prior arrangement would have been made to set the occasion. However conversations would usually be started up more naturally and would not be limited to any specific time, place or topics.

3. Conversations

This researcher found that conversations and informal discussions were more helpful in trying to understand the students' perspectives. These sessions complemented the interviews. It was very important in enabling her to understand any event that she felt was important. During the conversations, she could find out if she had made correct assessments of any incidents. What events had the students considered important? It helped her to be more aware of the issues that they thought significant. There were several different forms of conversation or discussions that she took part in or initiated:

(1) There were group conversations where she was a passive listener. She would be included in the group but the other members would have a lot to say so that it was worthwhile just to listen in.

(2) Sometimes in the group, she would join in when she thought appropriate but following the discussion. She would not change or steer the conversations.

(3) There were conversations which were started because the researcher had some questions to ask or was trying to seek explanations and information on the course or other related matters.

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(4) Tutorial discussions were also a good source of information.

The drawback to these informal discussions is in taking down notes. Any notes could only be written after the conversations which meant that she had to rely on her memory and judgement of what she thought she had understand from the conversations. To minimise these difficulties, notes were written as soon as possible after the conversation. Some of the conversations took place while walking down to or from class, before lectures or after it or at the library. However they were useful in cross-checking observations made, discussions held with Mrs. A and with other students.

4. Questionnaires

During the research, three different questionnaires were administered to the students in the Mathematics class. The first questionnaire (Appendix 4(1)) was a students' evaluation of the course and the lecturer. It was prepared by the Civil Department. They were given only to students from the Civil Engineering Department. It was given in the middle of the first term.

The second questionnaire was a data seeking questionnaire (Appendix 4(2)) prepared by the researcher. It was a series of questions about the students mathematical qualifications, entrance qualifications, present course and work experiences. The questionnaire was handed out in the second term.

The third questionnaire (Appendix 4(3)) was prepared by a member of the Mathematical Sciences Department. It was a pilot study and was not originally planned for these students. Mrs. A requested the questionnaires to be given to her students. This was also a questionnaire designed for students feedback and evaluation of the course. The results of the questionnaire

and any additional comments were made available to the researcher.

5. Other documents

Other documents were also used to supplement the data. These were the students' work record sheets handed out by Mrs. A. Mrs. A had given the students a work record sheet during the first week of term in which they were to record the chapters they had read from the programmed text, other books referred to, exercises that they tried, problems encountered and computer programs that they used. Copies of the sheets were given to the researcher.

The researcher had also obtained the attendance list to tutorials, marks for the mid-sessional tests (which were not compulsory and did not contribute to the final marks) and the borrowing list for the computer programs. The programs were designed by Mrs. A to help students with their foundation in Mathematics.

3.6 Organisation and Presentation of Data

Among the more serious criticisms against the presentation of qualitative research data, especially on a research based on participant observation, is that the researcher is able to manipulate the data to suit the focus or theory that he wishes to develop (McNamara, 1980). Without access to the research data, other concerned researchers would not be able to verify the data leading to the conclusions as only excerpts would be made available in the final written product.

In a response to this lack of evidence in supporting any interpretation of the research data, Stenhouse has suggested that the data should be organised in two stages:

(i) Representation

(ii) Presentation.

In the Representation stage, the data collected should be subdivided in two further categories:
(a) Case Data and (b) Case Record.

Data collected during the research in its raw form is termed the Case Data. This would consist of all the materials collected during the research. This would be the primary source.

Case Records referred to a 'parsimonious condensation' (Stenhouse, 1978) of the primary data. This would be an edited selection of the full data available. Stenhouse was strongly promoting that these Case Records should be housed in an archive where other Case Records from various researches would be made accessible to other researchers and the public. In this manner, the case study could be verified by other researchers, though, he stressed that only those who had been connected with the research should be allowed to write up the case study.

The Presentation stage was also subdivided in two further categories: (a) The Case Study and (b) The Analytical Survey.

According to Stenhouse (1978),

> *"The case Study is an interpretive presentation and discussion of the case, resting upon, quoting and citing the case record for its justification."*

and that ,

> *"The Analytical Survey is an attempt to draw together data from case records to make retrospective generalisations across cases."*

In the general organisation of this research data, the suggestions of Stenhouse have been taken up in the adoption

of his method but not fully supporting his definition of Case Study research (*vide supra* Section 3.1.3).

In this research, the Case Data would consist of the field notes (from observations, discussions and conversations), taped recordings of interviews and all other documents collected. The Case Records would consist of the selectively edited case data and would be made available for inspection.

This thesis consists of the Case Study. It would also attempt to present analysis of the data collected, describing how the results was interpreted, linking it to theory.

3.7 Analytical Techniques

There are many different styles of qualitative research which would require different ways to handle and analyse the data. Becker (1958) has described an analytical process which is in four stages. These are:

(1) the selection and definition of problems, concepts and indices
(2) the check on frequency and distribution phenomena
(3) the incorporation of individual findings into a model of the organisation under study,
(4) the presentation of evidence of proof.

He envisaged that the first three stages would be conducted during the fieldwork and the fourth stage to be taken up after its completion.

Glaser and Strauss (1967) developed and promoted an analysis technique which was at first mainly used in analysing sociological data. Their constant comparative method was considered more dynamic than Becker's linear sequencing stages (Hopkins, et al, 1989). The purpose of their analysis was to generate theory from the research data which was called

'grounded theory'. They had also distinguished four stages in data analysis, namely:

(1) comparing incidents applicable to each category
(2) integrating categories and their properties
(3) delimiting the theory,
(4) writing the theory.

Grounded theory has been used in educational research concerned with the social psychological consequences of school life with varying rigour and success.

Other techniques that have been used by educationalists include those of Woods (1986). He identified six leading aspects of analysis:

(1) speculative analysis
(2) classifying and categorising
(3) concept formation
(4) models
(5) typologies,
(6) theory.

In literature on qualitative data analysis, conducting data analysis simultaneously with data collection, was considered one of its most prominent characteristics (Becker, et al, 1961, Glaser & Strauss, 1967). Some early reflections and 'speculative' analysis on the data collected should guide the direction of subsequent data collection (Woods, 1986). Thus, further insights into the research problem could be achieved by '*moving backwards and forwards between observation and analysis and understanding*' (Lacey, 1976).

Bogdan and Biklen (1982), however, have identified two general approaches to analysis, which are:

(1) data analysis was conducted concurrent with data collection,
(2) data analysis was carried out after data collection was completed.

It was decided that since this research would mainly be concerned with the design and implementation of the Mathematics provision of the BTEC qualified students and the reality of the teaching situation, a synthesis of the techniques advocated by Woods, Bogdan and Biklen would be implemented. The techniques advocated by Glaser and Strauss were more suitable for research concerned with the sociological processes and relationships in educational settings.

Several techniques from analysis of data in the field was borrowed but the main data analysis was conducted after all the data was collected. Some ongoing analysis was done during the data collection, similar to Woods' 'speculative analysis' as this was necessary to direct and develop a research focus. This was determined by what is feasible and of most interest to the researcher.

The techniques implemented during data collection were:

(1) Making decisions to narrow the study.

It was already decided at the beginning of the research that the researcher would concentrate only on the class of BTEC qualified entrants, following almost all the sessions time-tabled in their course (lectures, tutorials, computer laboratory) with Mrs. A. The underlying focus is on the implementation of the Mathematics course but some attention was also given to the teaching of Mathematics and the students' mathematical learning during these sessions. By participating in these sessions, the researcher would be exposed to the same amount of feedback available to lecturers teaching the course.

Data was first collected widely so as to become more acquainted with the class, to understand the parameters of the setting, subjects and possible issues for the research focus.

(2) Making decisions to determine the type of study to be accomplished.

It was difficult to decide from the outset which type of qualitative research tradition would be followed. The researcher's own inclinations was towards a study that would enable her to describe the learning situation fully and be able to convey details of the students' interactions in class particularly with the lecturer who was teaching them Mathematics. In the earlier studies reviewed, this particular aspect of the learning situation was assumed understood but never described.

A decision was made to adopt a case study approach utilising qualitative techniques as described (*vide supra* Section 3.5)

(3) Developing tentative analytic questions.

(4) Data collection was planned with reference to previous observations.

(5) Comments were written about ideas generated and what was being learned in the field.

The bulk of the analysis was left after data collection was completed. The primary data, mainly from field notes and transcription of the interview sessions was edited and represented as the Case Records. Some tentative analysis which was termed as 'speculative analysis' by Woods (1986), was made simultaneously with data collection as the researcher used this procedure to guide and focus the research.

An analytical review of the data collected was made at regular intervals during the research. The researcher had taken time off from attending the teaching sessions in order to look through her notes and listened to the recordings of interviews. The purpose was to identify further issues to follow up and to

check on her own conduct in the class and during interviews. As an example, she found that during the earlier interviews, she had become enthusiastically involved in some of the interviews cum discussions almost forgetting the research purposes of the occasion. Listening to the tapes had helped her to improve her interviewing techniques. Appendix 5 gives a record of her attendance during the research and when she had taken time off to organise her notes.

Notes made during interviews and observations were fully written out by hand as soon as possible after the events. Full transcription of the recorded interviews and the field notes, however, were properly typed out during the term holidays. The researcher had transcribed all the interview recordings with members of staff in full. Earlier interviews with the students were treated similarly. Later interviews with the students were treated differently. She would go through the tapes and note by using the counter, where any suitable sections were found. Sections which she judged of interest were listed with a summary of the contents. The process is less time consuming than a full transcription. She had a total of thirty-three recorded student interviews (some students were interviewed twice) which were of at least forty minutes duration each. She would go over each interview repeatedly (at least three times), checking through the list in order to ensure that she had not overlooked any important or interesting detail. She would usually allow some time to pass before each subsequent checking to reduce the possibility of any lingering preconceived and/or mistaken understanding of the previous transcription from affecting the interpretation.

Data organisation and the practical ways of handling it were based on the suggestions from Bogdan and Biklen (1982). Thus the field notes were typed out in paragraphs with a wide margin for comments. They were numbered and arranged chronologically according to when they were collected. The researcher grouped the data collected from lectures, tutorials and conversations on a weekly basis. Other documents collected,

such as handouts from the various staff interviewed, name lists, were kept separate from the field notes. The transcribed interviews were also kept separate but were prepared in a similar manner.

As mentioned earlier, the researcher had read and re-read the notes periodically and had noted any incidents. These were classified and grouped under assigned headings. At first these headings were a general identification procedure to sort out items from the transcribed data for example, which section were descriptive, explanations or merely opinions of the interviewees. These data then were grouped again under headings which described the events that were taking place, for example, under the heading, Administrative Problems, several difficulties that Mrs. A had with the Administration of the course were listed. Later, these events were compared to other administrative influences to the progress of the course. The researcher adopted the technique of classifying and grouping the data as this procedure would help in the building of the curriculum model.

The analysis conducted during the research had enabled the researcher to focus the research on the curriculum development of the Mathematics course. Her early attempts at analysis was kept at a substantive level which focused on the setting under study only. She had speculated on some relationship between substantive theory and formal theory but delayed a more determined effort to establish this relationship until after the data collection was completed.

Time constraints did not permit the researcher to pursue a thorough process of respondent validation. The students were out on vacation. Instead, she had conducted several discussions with Mrs. M during the period of writing up and had asked her to check the analysis of the research as well as to read through the whole thesis.

3.8 Validity and Reliability

Criticisms against qualitative research focus on its subjectivity as a source of bias in the data reported or in any accounts produced. Researchers are confronted with questions of validity and reliability of an observation-based research. Critics raise questions on the generalisation of any research findings. The focus is on its **external validity.** Could the results obtained be generalised to other situations? The research aims for this study exclude this generalisation. It is a study to understand a learning situation and the factors that affects the learning and teaching process of a particular class in a particular University. The **internal validity** of qualitative research findings is also questioned. How far does the researcher's presence affect and influence the generation of data?

In addressing the issues of validity, the focus would be on the representation of data. Do the results represent the true situation? The considerable time spent in the research setting would enable the researcher to become attuned to life within the research setting. Her presence would become natural and acceptable. The effect of an observer's presence could not be removed totally. All the events under study becomes settings with a researcher present. Thus the study of the natural setting is an elusive research aim unless one is invisible. In being aware of the notions of reflexivity, reactivity and indexicality, this researcher hopes to present an account of the research that would be considered valid.

What are the criteria for assessing qualitative research? Proponents and practitioners of qualitative methods maintained that this research should only be judged with its own verification procedures. Assessments of qualitative research using quantitative procedures would be totally inappropriate (Bogdan & Biklen, 1982). The two research methods have developed based on different assumptions, techniques and strategies. Methods advocated and practised by various

researchers to judge the credibility and quality of qualitative research includes the following:

(1) Triangulation

This is using multiple strategies in the research. Data accumulated through different techniques are compared, checked and cross-checked. Accounts of the same event by different participants are collected and compared. This would enhanced the accuracy and comprehensiveness of the data.

(2) Reflexivity.

Researchers will attempt to address and identify their own subjectivity. These reflections would be related and thus made known to the readers of the account. Some changes due to the effect of the observer in any research or experiments is unavoidable. The qualitative researcher would attempt to minimise and record his subjectivity.

(3) Informant validation.

The processed account of the relevant research material is returned to the respondents for their comment. With this strategy, the participants are allowed to judge the accuracy of the researcher's account. Has it captured the reality from their perspectives?

These methods will be used in this study to satisfy the demands of rigour and verification associated with the research methods.

Reliability of the research findings is a notion concerned with the consistency of results obtained by different researchers studying the same setting independently. This researcher could not accept the criteria of reliability as it has been defined for

quantitative research. Could this research be replicated? The very concept of replication is derived from the assessment procedures of quantitative research. In studying this learning situation, it is difficult to ignore the unique nature of the setting. How could such a 'time-embedded' (Stenhouse, 1978) situation be replicated satisfactorily if at all.

Since the term reliability in the traditional sense could not be applied to qualitative research, the emphasis should be shifted to the 'dependability' and 'consistency' (Lincoln & Guba, 1985) of the results obtained from the data. Several techniques could be implemented to enhance the consistency and dependability of the research data, such as:

(1) Giving full explanations of the assumptions and decisions taken during the study, her position with respect to the group being studied, the basis of selecting informants, a description of them, and the context of the setting chosen.

(2) Triangulation (see above). This would enhance both the reliability and internal validity of the research.

(3) Presenting a description of the methods used in data collection and its analysis.

By following the techniques described above, it is suggested that it would enable the reader to make judgements and to examine the reliability and validity of the research methods.

CHAPTER 4

A CASE STUDY: MATHEMATICS PROVISION FOR NON-GCE A LEVEL QUALIFIED ENTRANTS TO AN UNDERGRADUATE COURSE IN ENGINEERING AT LUT.

4.0 Background

This case study concerns a one year (October, 1990 to July, 1991) provision in the teaching of Mathematics for undergraduate students on the first year courses in Engineering at LUT who had entered with non-GCE A level qualifications, of which the majority had BTEC qualifications. The provision was considered by the involved members of staff as an experiment to overcome some of the problems associated with the large variation in the students educational background, especially with respect to the level and type of qualifications in Mathematics that these students had.

In previous years, the University had taught all its Engineering students separately within their departments as they did not have a common first year course. The Mathematics was taught in each of these Engineering Departments by staff of the Department of Mathematical Sciences. Traditionally, the majority of entrants to the Engineering courses had GCE A level qualifications, including one or two in Mathematics. However, there was a minority which had alternative qualifications. The number of non-GCE A level qualified students had increased significantly in recent years. Most of these non-GCE A level qualified entrants could be considered as 'mature' students as they usually had taken a longer route to gain suitable entry qualifications to the University. 'Mature' students, here, is defined as "*students who have had a substantial break between school and further education in the higher sector*" (Elton, 1975).

Previous experience of staff in teaching Mathematics to groups with mixed entry qualifications, had enabled them to perceive certain students' difficulties. Among these,

"The difficulties experienced by many students in this category will be well known to all those who try to teach mathematics to those with mixed entry qualifications. Some need extra work on foundation topics to fill gaps in their knowledge while others require further practice in recently acquired skills."

(M.P.A. Green, 1991)

Staff had also identified some difficulties in dealing with the variations in the students' abilities and background knowledge in Mathematics (*vide infra* 4.3.2). In the past, there had been other attempts to resolve some of these problems. Prior to 1975, the main course in Engineering began in January. The Department of Engineering Mathematics (this later merged with the Department of Mathematics in 1988 to form the present Department of Mathematical Sciences) used to run foundation courses in Mathematics in October for students who had needed extra help with Mathematics, especially those with ONC/OND qualifications (*vide supra* 2.2). These courses were dropped when all the main courses began in October. Instead, the Mathematics lecturers, organised some extra lectures during the first term to cover background topics. These lectures were conducted parallel to the main course. Due notice were given to students as to which particular topic was to be delivered.

"However this did not seem to be the answer, since many of the students who really needed these were either unable or unwilling to attend, and because there was an obvious loss of continuity in the order of treating topics. This caused early lack of confidence in some students, who seemed to be struggling thereafter. The most tenacious coped and often did well, but many were content with writing mathematics off at an early stage as a totally incomprehensible element of their main course."

(M.P.A. Green, 1991)

With these past difficulties, the members of staff involved with the teaching of Mathematics and the Engineering Education of such students were convinced that they should be given more help with their Mathematics. They considered teaching these students in a

separate group, at least for the first year, in Mathematics. Three Engineering Departments, Mechanical, Manufacturing and Civil, agreed to set up such a group for the academic session of 1990-1991. The students were allocated extra time as compared to the main group (GCE A level entrants). The aims of the course as described by staff was to bring the level of their knowledge and competence in Mathematics to the same level as that of their colleagues in the main group. All the students catered for in this provision were to rejoin their colleagues in the second year. The Mathematics syllabus for all the groups were the same and there was to be a common assessment at the end of the first year.

At a later stage, the Department of Electrical and Electronics decided that their students were to participate in the provision as well. All students who had entered with non-GCE A level qualifications were at first designated to join this group though there was no compulsion to stay. Each student was allowed to attend either class, the main group or the special provision, in order to decide which class to follow. However any request for a transfer was to be referred to the course tutor whereby the final decision was made after some discussions were held. As such, the number of students in the special class in the first couple of weeks was variable and finally settled to about sixty-five students. The exact number could not be confirmed owing to the ensuing changes and developments in the course itself. This will be discussed in the following sections (*vide infra* 4.5).

Although the Engineering Departments and the Department of Mathematical Sciences had agreed on the separate group, it was not to involve extra staff. Thus, the Department of Mathematical Sciences had to reorganise their teaching staff responsibilities to accommodate the new group. The main groups from the Mechanical and Manufacturing Engineering Department were combined and was taught together. This ensured that one of the lecturers would be free to teach the special class.

The provision was not specifically called by any name though in interviews, staff referred to it as the 'BTEC group'. It was agreed that the class was to be given more time to cover the same syllabus

as compared to the GCE A level groups. They were to have five contact hours which consisted of three hours lectures, 1 hour tutorial, and 1 hour for 'Surgery'. Surgery sessions were designated so as to allow the students to have some personal attention. These sessions were to be time-tabled but the students' attendance were optional.

The various Mathematics syllabuses of the first year Engineering courses were mainly very similar to each other though there were some variations to accommodate the needs of particular departments. For the 'BTEC group', certain foundation topics had to be included, such as trigonometry, algebra, functions and an introduction to calculus. The specific different topics, apart from the main core of the syllabus, needed by the various Engineering departments were as follows:

1) Civil Engineering and Manufacturing Engineering Departments: An introduction to Statistics
2) Electrical and Electronics Engineering Department: Vector Analysis
3) Mechanical Engineering Department: No additional topic.

4.1 Focusing the Research

Interviews and discussions conducted with various members of staff at LUT who were directly involved with the provision had presented the researcher with a focus. It appeared that the special provision was intended mainly for BTEC qualified students as nearly all the staff interviewees referred to it as the 'BTEC course'. However, subsequently the researcher observed that there were other students with other non-GCE A level qualifications in the class. The number of such students were small when compared to the BTEC qualified entrants.

As the BTEC qualified students were in the majority, the design of the course was apparently based on assumptions about their past mathematical learning experiences. A description of the BTEC courses,

qualifications and the Mathematics deemed suitable for entry to an Engineering degree course will be given (*vide infra* 4.2.4) in order to appreciate the background mathematical qualifications that these students had. Some discussions on the students' BTEC or other mathematical learning experiences prior to entry to university will be given (*vide infra* 4.2).

Interviews conducted with some of the respondents during the research will also be presented in this chapter. These include: Admissions tutors of the Engineering departments at LUT; lecturers teaching Mathematics to first year students at LUT; course tutors of the Manufacturing Engineering Department; University officers and some of the BTEC qualified students.

Other interviews conducted (*vide* Appendix 2) with the staff at Further Education (FE) Colleges helped the researcher to find out from the teachers involved in the implementation of the BTEC courses, what were the problems they faced. Information on BTEC were supplemented by further readings on relevant BTEC publications. Information from these interviews, however, implied that students on BTEC courses at these FE Colleges, were already weak in Mathematics upon entry to the colleges and that the BTEC Mathematics courses provided for them did not allow much time for these students to cover the topics required. The FE teachers interviewed thought that the students needed an extra unit in Mathematics if they were to cope with Mathematics in courses at degree levels. BTEC had designed such a unit, called NIII Mathematics (1 unit) but its implementation was left to the discretion of the FE Colleges.

From the beginning of the research, the researcher was aware that the students coming into the degree courses with BTEC qualifications were considered by the University and College staff to have a weaker Mathematics background than GCE A level entrants. The explanations given to the researcher by members of staff at LUT were that these BTEC students did not spend enough time on Mathematics in the BTEC courses which agreed with the views of FE staff. The information gathered from the FE teachers indicated the possibility that the

students had a weak Mathematics background even before doing the BTEC courses at FE Colleges.

4.2 BTEC Courses

4.2.1 Introduction

At the outset of this research, it was decided that the researcher would identify the various non-GCE A level qualifications. Checking through UCCA Statistical records, the possible entry qualifications categories that has been accepted by British universities in the past five years were: BTEC ONC/OND and HNC/HND, SCOTVEC (Scottish Vocational Certificate of Education), Scottish Higher Nationals, and others which were not specified but only represented a very small percentage of entrants. The Scottish Higher Nationals are the Scottish equivalent of Sixth Form qualifications and thus considered at par with the GCE A levels by UCCA.

The researcher's earliest efforts then were to find out which of these non-GCE A level qualifications would be accepted as entry qualifications for the Engineering undergraduate courses at LUT. She made some efforts to find out about ACCESS courses but found some evidence that indicated that the number of students coming in via these courses would be expected to be very small; if indeed any entered by that route at all.

4.2.2 Background

BTEC courses has been operational since the merger between BEC and TEC in October, 1983. BEC and TEC courses were introduced in 1976, taking over from the former ONC/OND courses (*vide infra* 2.1). The courses were designed originally for work-related education for people to develop their potential within employment (BTEC, 1984). The BTEC courses were made easily accessible to such students by various programmes of study.

"Courses leading to BTEC's qualifications are run in colleges, polytechnics, companies and training centres throughout England, Wales and Northern Ireland."

(General information leaflet, BTEC, 1990)

The term 'centre' has been used by BTEC to refer to any institution that ran BTEC courses. These courses were unit based and could be studied full-time and part-time which included day-release, evening, block-release, sandwich and, where appropriate with open and distance learning. The quality and control on these courses were maintained by BTEC in four major ways:

(1) guidance

BTEC had standardised the curriculum and course/unit content through its guide-lines which also covers teaching and learning methods, course design, assessments and course/unit objectives.

(2) validation

Any centres that wished to run BTEC course had to gain approval and validation from BTEC.

(3) moderation

Suitably qualified individuals specially appointed by BTEC, called moderators, would inspect the courses. The inspection would be carried out three times yearly and would be reported in detail to BTEC. Moderators usually monitor 3-5 centres each in order to maintain consistency across centres.

(4) certification

Students final grades were checked/endorsed by the moderators.

BTEC has three levels of qualifications which are:

(a) BTEC First Certificate

(b) BTEC National Certificate and Diploma

(c) BTEC Higher National Certificate and Diploma.

Students could also take individual unit or study programme, to receive a Certificate of Achievement that may provide credit towards one of the qualifications.

4.2.3 Standard of BTEC qualifications

To appreciate the compatibility of BTEC qualifications as compared to the GCE A level qualifications as entry qualifications to degree courses, tables 6 and 7 are reproduced from the official 'UCCA : Examinations and Grades, Notes for University Selectors 1989-90". It should be noted that neither BTEC nor UCCA advocate a direct comparison of scores for entrance to university due to the inherent differences between the two systems. Table 6 gives the current designation of BTEC qualifications and their equivalent designations under the older system. Table 7 gives the breakdown of the BTEC courses, minimum entry qualifications, course duration and the generally recognised standard of the relevant BTEC qualifications.

For the purposes of admission to university, UCCA states that N level is equivalent to level III of the previous TEC qualification and H level guarantees completion of a standard equivalent to the old level V.

Table 6

BTEC Qualifications Designations

Current Qualification	Former TEC Level	Presentation Designation
BTEC First	Level I	F
BTEC National	Levels II & III	N
BTEC Higher National	Levels IV & V	H

Table 7: BTEC Course Standard

BTEC Course	Age of Entry	Minimum Entry Qualifications	Course Duration	Generally Recognised Standard
BTEC First	16	No formal qualifications stipulated but some centres demand GCSEs/GCE O levels	1 or 2 years	BTEC First leading to a BTEC National which is normally 4 O levels/4 GCSE entry
BTEC National	16	4 GCE O levels or 4 GCSEs	2 years or more	GCE A Levels
BTEC Higher National	18	GCE A level having studied 2 A levels (although majority of centres demand 2 good A levels)	2 years or more	Many employers accept Higher National as Pass Degree A levels in standard, and because of its work related nature, some industries prefer it to a degree. Universities and HE institutions admit at their discretion HN holders to years 2 or 3 of their degree courses.
BTEC Continuing Education (CE) Certificates and Diplomas	19+	For a CE Certificate, an educational and experiential background equivalent to that of a BTEC National holder. For a CE Diploma, an educational and experiential background equivalent to a BTEC Higher National holder in the subject area.		An adult post A level qualification (work related) When combined with BTEC HNC or HND, an adult honours degree level qualification in a specialised field, recognised by professional bodies for membership.

4.2.4 University entrance requirements for students with BTEC qualifications

The UCCA handbook of guide-lines to Admissions tutors reminds tutors that offers should be made with consideration to the student's course tutor's report and grades in relevant units. Any relevant work experience should also be taken into account.

The relevant sections from the 'October 1991 entry' prospectus has been included in Appendix 3. Generally, all the Engineering Departments at LUT state that students with BTEC qualifications would be considered individually and that the normal requirements would include a good pass mark in Mathematics at level III (85%+) and good overall performance in at least three other level III subjects.

The Manufacturing Department is the only Department that categorically states, "The department welcomes applications from candidates taking BTEC qualifications".

Comments

The UCCA guide states that generally the BTEC Nationals qualifications are comparable to the GCE A levels and that the BTEC Higher Nationals could be considered as Pass degrees. However, the researcher found that staff at LUT did not consider the BTEC qualifications as such with some staff strongly disagreeing with the comparison. The BTEC courses were recognised as a different educational route toward entry to degree courses and students applications were considered on an individual basis. As an example, students with BTEC HNC/HND would usually enter into the first year of the course unless they specifically request entrance to second year. Their application would be considered on individual merit. However, some of the Engineering Departments at LUT would allow overseas students with good diplomas from their individual country to enter the second year directly, again based on individual merit. Overseas students from Malaysia and Singapore had managed to do this in the past. However the researcher, being Malaysian knew that

students from these regions would have taken only three years full-time to gain their diplomas as compared to the four years or more of study followed by the BTEC HNC/HND candidates assuming they had started with the BTEC First Certificate. It has to be stated, though, that most Diploma courses in Malaysia at least, would have Mathematics as a core subject with syllabuses comparable to the Pure and Applied Mathematics Combined at GCE A level. The same claims were made by UCCA about the standard of the BTEC HNC/HND, and in fact, they were considered post GCE A level qualifications.

These observations further supported the view that not only there was a large variation in the educational experiences of students in the special class but there were variations even in the BTEC courses and Mathematics qualifications that the students possessed.

4.3 Interviews with LUT staff

4.3.1 Introduction

Early interviews conducted with LUT staff, namely, Mr. E, Mrs. A and Dr. B, indicated that the provision that was implemented were targeted mainly at students with BTEC qualifications. Interviews with the colleges' teachers also indicated that these students would have problems with Mathematics at university level. As such, later interviews with the LUT staff were focused and concentrated on the reasons for increased BTEC students entry, the difficulties the students with such qualifications had faced in the past and, what they thought of the current provision in Mathematics for students with these qualifications.

Interviews with the staff included the following individuals:

(1) Mr. E, the Senior Assistant Registrar;

(2) Admissions tutors:
   (i) Dr. F, Manufacturing Engineering Department,
   (ii) Mr. G Civil Engineering Department,
   (iii) Mr. H, Mechanical Engineering Department,

(3) Mr. K, course tutor of the Electro-Mechanical Power

Engineering,

(4) lecturers from the Mathematical Sciences Department who were teaching the various Engineering groups:

(i) Mrs. A, who was teaching the provision under study

(ii) Dr. B, who was the main member of staff responsible for the set up of the provision as well as being in-charge of coordinating of the Mathematics teaching between the Mathematical Sciences Department and the various Engineering Departments. He also taught Mathematics to the Civil Engineering group.

(iii) Mr. D, who was teaching students from the Electrical Engineering Department, Chemical Engineering Department and the Science and Engineering group.

(iv) Dr. C, who was teaching the Manufacturing Engineering Department and Transport Technology

(5) Course tutors from the Manufacturing Engineering Department,

(i) Dr. L, Course tutor, Electronics and Manufacturing Engineering,

(ii) Dr. M, Course tutor, Design and Manufacturing Engineering,

(6) Dr. N, senior lecturer, Manufacturing Engineering Department

4.3.2 Students' difficulties and progress through the course

In the literature reviewed (*vide supra* Chapter 2), the students with ONC/OND and more recently BTEC ONC/OND were generally identified as those who would most likely have difficulties with their Mathematics in a first year Engineering degree course. During the interviews with the LUT staff, the same views were expressed by all the respondents. However some made the distinction that the students were usually weak in background but not necessarily lacking in ability.

Dr. B was the central figure in the setting up of this provision. He was also the co-ordinator for the Mathematics teaching to the Engineering departments. In an interview with Dr. B, when asked to comment on the statement that for the Manufacturing Engineering Department, students with BTEC level III were considered as traditional entry students, he replied,

(Extracts from interview, Dr. B, 26/6/90)

"Well this again, you see, can I just put in a piece of historic information for you because one goes back 20 years which is quite along time (he clears his throat) *and in those days you had what was called the National Certificate for people who did not follow A levels and there was always a problem with those students because although they had covered very many good topics in Mathematics, the hours they had spent after the age of 16 was considerably less than their A level student contemporaries. So although what they had done was useful, they, due to the fact they spent much less time on it, they could not have covered it in sufficient depth compared to the A levels who have a full grasp of it."*

In a later part of the interview Dr. B continued on the reasons why the student found Mathematics at university level difficult to cope with at first:

(Extracts from interview, Dr. B, 26/6/90)

" Now we have found that the problem with these TEC candidates is first of all confidence. As soon as they encounter a different style of teaching from that to which they've been used they feel inferior and they find it very hard to accept that if they battle away consistently through the year they will achieve good results..."

" ..again at university one tends not only to give standard examples to reinforce the techniques but also perhaps one just stretch them a little further and they worry about this, that they cannot see it easily therefore it must be beyond their capabilities..."

Mrs. A has been teaching Mathematics to various Engineering first year students for the last 10 years. She commented in her interview that the BTEC syllabus apparently covered similar topics as compared to a general GCE A level syllabus but,

(Extracts from interview, Mrs. A, 14/6/90)

> *"It's not so much the topics, they tend on paper, you could pick up a BTEC syllabus and you could think that they covered virtually the same topics as the A level but it's the depth to which they do the topics and the way in which they do the topics. Uh..an awful lot of the students that identified themselves to me as BTEC students umm..they liked this book* (she leaned down to retrieve a book from her book shelf) *which is Engineering Mathematics by Stroud and the reason they like it, is because it's what I call a safe book. It teaches them something, it does an example and then it gives them an example to do and all that it does is change the numbers and they feel safe on that kind of examples and I find that BTEC teaches in this kind of way and it never gives the example where you got to take another step and do something where it's not quite so obvious how you use your Mathematics that you ought to learn and it's this stepping out to use your maths on a problem that isn't identical to the problem that you've seen before, this is always difficult for everybody."*

She also described the need to build the students confidence and the possibility of the students falling behind in their work,

(Extracts from interview, Mrs. A, 14/6/90)

> *"..I think we need to use a variety of learning methods for this er.. as far as possible tailored to the individual.....and one of the big things I think that this could do would build up the confidence of these students because er... this is the worst aspect of it that they fail in their first week , they go to a lecture, they don't follow what's going on in a lecture and they go to a tutorial, they can't fill a..all the gaps quickly enough, they try to do something themselves and they can't cope, they get further and further behind and each lecture is a little less*

meaningful and a..perhaps even before we realise they're in difficulties, they consider themselves failures and I think this is a great shame because a lot of good quality...people there [R: hmm yes]

This view of the BTEC students as having not spent time on Mathematics to a comparable depth of study as compared to the A levels were reiterated by all the lecturers involved in teaching Mathematics as well as the admissions tutors.

During his interview, when Mr. D was giving the reasons for the weakness of the BTEC students, he emphasised that,

(Extracts from interview, Mr. D, 29/10/90)

"The reason they're weak, they're not necessarily they're not necessarily weak, that's what we've got to remember, the reason they're weak, no not weak in ability but weak in background, they haven't done so much Mathematics before [R: yes] *that's the reason they're weak and what they need is more time to to absorb the sort of background, the knowledge that the other students have got."*

Mr. K shared the same opinions and in a part of an answer that he gave, he said:

(Extracts from interview, Mr. K, 15/10/90)

.....I think this is particularly with Mathematics which uhmm you know, which is inevitably inevitably taught at a fairly rapid pace and A level students have been.. have probably a third of their education in the previous two years devoted exclusively to mathematics where as the BTEC students, even with 2 hours Mathematics probably wouldn't have had more than 20% of their time devoted to Mathematics perhaps even slightly less.....

It was very clear that the interviewees were unanimous and were very certain about what they thought were the reasons for the difficulties faced by the BTEC students in Mathematics.

These were:

1. Lack of knowledge. They have not covered the topics in Mathematics to the same depth of study as the students who followed any GCE A level syllabus.
2. Lack of confidence. This would supposedly become obvious when,
   (a) they encounter the different styles in teaching at university as compared to that at college,
   (b) they were given examples or problems in Mathematics that were not straight forward.

During an interview with Dr. F (30/4/90), Admissions tutor for the Manufacturing Engineering Department, he said that the BTEC students would usually find Mathematics difficult in the first year but would be able to cope in the following years. Mathematics. Mr. G, the Admissions tutor for the Civil Engineering department, and Mr. K, shared the same views,

(Extracts from interview, Mr. G, 19/10/90)

" ...and the the BTECs they can by the time they reach 3 years they they have distributed themselves through the through the course [R: yes] *they don't although they may start at the bottom they don't end at the bottom, they don't end at the bottom, they they find their true level and position ya."*

(Extracts from interview, Mr. K, 15/10/90)

"....so far with one exception, I haven't been seriously let down and the one exception I think was more than just mathematics, the student really wasn't strong enough anyway.."

All the admissions tutors interviewed also said that in the long history of having students with such qualifications in the university, the students were well spread out across the various degree categories in the final year. They felt that this proved the point that they were able to progress in the course but the most difficult year was the first year and the most difficult subject for these students was Mathematics.

Other non-GCE A level qualified entrants, especially from Hong Kong, Singapore and Malaysia would have entered the universities with Diploma qualifications. The tutors claimed that these students would not usually have any problems with Mathematics. In fact in some of the departments, notably, Manufacturing and Civil, these students could opt for a direct entry into second year of the course. The number of such students were usually very small compared to the total number BTEC entrants.

4.3.3 Help and support

LUT has always had a group of students in the past coming in with non-GCE A level. Their difficulties in Mathematics were acknowledged. In the past there had been other efforts to provide the help and support for the students to cope with university Mathematics.

Up to the 1970s, Dr. B said that the students with ONC qualifications were taught separately and were given an extra hour a week for Mathematics. However as the Engineering departments had larger students intake, these students were kept with the main stream group.

(Extracts from interview, Dr. B, 26/6/90)

> *"It was then felt by the Heads of those departments that they wanted the students to be kept in with the main stream groups and so therefore you had all the Civil Engineering students together whether they were taught whether they had come in with A levels or National Certificate and to me as a teacher that presented a number of problems because we did not wish to go too quickly through the material which would be a disadvantage to the National Certificate entry, on the other hand if we went too slowly we would bore and turn off students with A levels so it was a difficult path to steer, and because of this we devise a scheme of teaching whereby the computing and numerical methods will be taught alongside the calculus-based methods."*

Mrs. A started working in LUT in 1980 and remembered that,

(Extracts from interview, Mrs. A, 14/6/90)

"Well yes when I started here the main Engineering course started in January..and in October, there were a group of students who were....working in a centre for industrial studies which is on..was on the campus, it's closed now and ...I used to have these students on Friday first thing Friday when they did extra mathematics and Science and I used to run a course through first term for about 20 hours"

Sometime in 1978, the first group of students graduated with BEC and TEC Certificates/Diplomas which has replaced the National Certificate. These were then replaced by BTEC when the BEC and TEC merged together in 1983. In the past 10 years, Dr. B and Dr. C had put on some extra lectures each year in the first term on topics that were either not covered in the BTEC syllabus or not covered to the same depth as in the GCE A level courses. Dr. C said,

(Extracts from interview, Dr. C, 27/11/90)

"I used to in fact do these topics along side the rest of the course and this worked reasonably well but the..we decided it was much better if you could do more slowly emm..by themselves [R: umm..] because they can cover the same amount of materials but they would have longer to do it in.."

Dr. B described the previous situation thus,

(Extracts from interview, Dr. B, 26/6/90)

"It was a very much a patchwork job. One has to face the limitations of the time the Engineers were prepared to allow you with their students and the compromise we reach was that in the first term I will provide one extra lecture per week on topics which were in the A level syllabuses which were not covered by our first year course but which were reckoned to be necessary to build the bridge. For example, the Binomial Theorem would be one or Trigonometric Identities like sine squared theta plus cos squared theta equals one, things that follow from that which are not important in themselves but when you do certain engineering problems are useful as short

cuts to calculation and if you find students are being held up not by the topic you are teaching him but by the background material, this is obviously a disadvantage to him. So it help to a certain extent but it wasn't really satisfactory because you're still having to teach the main stream at pace with the others."

The problems of the BTEC students had been under discussion among the lecturers from the Engineering Departments and the Mathematical Sciences Department. All the admissions tutor interviewed mentioned that they had discussions with Dr. B about the students' problems as well as the provision set out for the October 1991 intake of BTEC qualified entrants. Mrs. A and Dr. C both mentioned that they had discussed the problems with Dr. B and fully supported the scheme that was implemented.

As the lecturers had identified 'lack of confidence' as one of the main problems of the BTEC students, Dr. B said that he had hoped that the new course would allowed the students to retain their confidence long enough to pick up the necessary skills. Mrs. A felt that with this arrangement they would be able to teach the students in a more ordered manner. She would be able to teach the students any background topics required before moving on to the first year Mathematics syllabus. She said that one of her past difficulty was to identify who the BTEC students were. They were not identified to her by the department. In the past, students would identify themselves to her when they were having difficulties with the mathematics. If the students were already together in a class, she felt that she would be able to concentrate on their mathematical difficulties. She also thought that such students would need to be taught with a variety of teaching methods, other than lectures and tutorials, that would enabled her to identify and help individual problems.
Dr. F, Mr. G and Mr. K had expressed their full support for the special provision for the BTEC students in Mathematics because in Mr. G's opinion, (Extracts from interview, Mr. G, 19/10/90)

"....so when we have to, all the maths was done together, the BTEC people found it difficult and usually work towards the bottom of the year..."

These were:

1. Lack of knowledge. They have not covered the topics in Mathematics to the same depth of study as the students who followed any GCE A level syllabus.
2. Lack of confidence. This would supposedly become obvious when,
   (a) they encounter the different styles in teaching at university as compared to that at college,
   (b) they were given examples or problems in Mathematics that were not straight forward.

During an interview with Dr. F (30/4/90), Admissions tutor for the Manufacturing Engineering Department, he said that the BTEC students would usually find Mathematics difficult in the first year but would be able to cope in the following years. Mr. G, the Admissions tutor for the Civil Engineering department, and Mr. K, shared the same views,

(Extracts from interview, Mr. G, 19/10/90)

" ...and the the BTECs they can by the time they reach 3 years they they have distributed themselves through the through the course [R: yes] *they don't although they may start at the bottom they don't end at the bottom, they don't end at the bottom, they they find their true level and position ya."*

(Extracts from interview, Mr. K, 15/10/90)

"....so far with one exception, I haven't been seriously let down and the one exception I think was more than just mathematics, the student really wasn't strong enough anyway.."

All the admissions tutors interviewed also said that in the long history of having students with such qualifications in the university, the students were well spread out across the various degree categories in the final year. They felt that this proved the point that they were able to progress in the course but the most difficult year was the first year and the most difficult subject for these students was Mathematics.

He also said that because of the provision he was able to be more flexible in choosing new students with BTEC qualifications. He said it was difficult for students to compete with the GCE A level students as their educational background were totally different with respect to teaching methods and length of time available for Mathematics. He had hoped that with the new provision, the BTEC students would be able to cope with the Mathematics as they could usually cope with most of the other subjects. Mr. K too felt encouraged by the efforts of the Mathematical Sciences Department to give more assistance to BTEC qualified entrants. He stated that he had been fairly strict in placing students either in Mr. D's or Mrs. A's class. All GCE A level qualified entrants were put into Mr. D's class and BTEC qualified students irrespective of their grades and levels were put in Mrs. A's class. It should be noted that Mr. K was only concerned with students on the Electro-Mechanical Power Engineering Course.

Only Mr. D was not too happy with the special course that was implemented. He was interviewed on 29/10/90. For the last ten years, he has been responsible for teaching students in the Electrical Engineering Department from the various courses: Electronic and Electrical Engineering, Computer and Systems Engineering, Electro-Mechanical Power engineering, and students from the Electronic and Physics course as well as students doing Engineering Technology and Science.

As soon as the interview started, Mr. D talked of past efforts, about 20 years ago, where students from the different Engineering departments were lectured to in a combined group. Then the students were divided into an fast stream (A stream) and a slow stream (B stream). Then the students most likely to enter the slow stream had ONC as this was before the days of BTEC. He said that he had thought that the present scheme was mainly for the Mechanical and Production Engineering students and that it was not designed for his Electrical students. He also said that he did not think the scheme will work as the number of hours of lectures assigned to the time-table was still not enough.

(Extracts from interview, Mr. D, 29/10/90)

R: *".....Now in theory Mrs. A is supposed to have 5 contact hours, she's got 4 lecture hours er..3 lectures, 1 tutorial and 1 surgery, are you suggesting that it's not enough?"*

Mr. D:*".....Now I have exactly the same with the group I'm teaching, I have 3 lectures, 1 [R: tutorial] problem class which isn't, well you could call it a tutorial but that would be the wrong use of the word, when it's 150.. 160 students but but they..each student has a lecture with me then they have 1 hour a week where I would go through problems.....*
so nominally they have the same exactly the same teaching time as Mrs. A has with hers, the only difference is that of course that that since I've got a much larger group of students emm..Mrs. A has a smaller group therefore in terms of actual availability for the surgery and that sort of thing, she does get more time in that sense but as we (inaudible) actual time tabled hours, she's time tabled 5 hours a week with the group, I'm time tabled 4 hours a week with the group, I feel that for the system to work, Mrs. A should have 4 lectures a week plus whatever we had on, 4 4 actual lectures to cover the material in the syllabus."

He repeated his opinions that the students with weaker background should have more teaching time several times during the interview.

(Extracts from interview, Mr. D, 29.10/90)

Mr. D:*".....if we're going to make separate arrangements for weaker students then I very very strongly feel and this is no criticism of Mrs. A but I do strongly feel that the way it should be done is how it was done 20 years ago, that we should find more time for these weaker students..."*

The mathematical syllabus for the Electrical Engineering students were slightly different as compared to the other Engineering groups. The contents for the first two terms was similar but they needed Vector Calculus in the third term.

(Extracts from interview, Mr. D, 29/10/90)

R: *"so what would happen to the students in Mrs. A's class, but not in your class because they will not be doing vector calculus"*

Mr. D: *"Well the (inaudible) in the Department is that they're a bit worried about whether the scheme is going to work or not and they're looking into it but they will certainly come back into my lectures in the third term because they want to do Vector Calculus.*

R: *"So you mean it's very flexible?"*

Mr. D: *"It's very flexible at the moment I think it's all very experimental and I..you just..(inaudible) into it to see what happens but I didn't really understand anything about this scheme. I know it sounds surprising but I wasn't I wasn't consulted really about this scheme and I didn't realise it was running until term began.*

Mr. D was not happy that his students were taken out of the main group as he felt that their entry qualifications were slightly higher than the other departments. Most of the BTEC students had come in with BTEC qualifications at HNC or HND levels. He also voiced his concerns that the students were taught separately but would be sitting his examination papers at the end of the year. He also emphasised that he was not criticising Mrs. A but the system as it was set up. He also felt that if his students were to be taken out, he should have been consulted about it. He expressed his worry that it would be difficult for Mrs. A to teach a group of students who would have broadly similar syllabuses but not necessarily the same.

There was some confusion as the scheme started when some students from the Electrical Department came along to the first lecture. Mrs. A was not sure whether they were supposed to be in her group.

When Dr. C (27/11/90) was asked about the possibility of the Electrical students going back to Mr. D in the third term, he was not very sure.

(Extracts from interview, Dr. C, 27/11/90)

Dr. C: *"Er...I don't know what D means really, does he mean he wants to get his students back er.."*

R: *"I'm not really sure because I was just recording what he said and he thinks that he's getting them back, I mean I passed that information to Mrs A and Mrs. A was not sure as well, I'm wondering if anybody else knew"*

Dr. C: *"No, he hasn't said anything to me about it perhaps because he teaches mainly the Electrical [R: yes, he does] and in fact the ones in Mechanical Engineering EST that's Engineering Science and Technology, seems also to go with the Electrical Engineers because they need the Vector Analysis whereas the Mechanical Engineers as you know, now has been put in with my Manufacturing Engineers because they are very similar really. Er..they diverge more in the second year but at first year they are the same syllabus more or less so we're a able to put them together, I mean the problem is we're going against our own philosophy a (inaudible) of course because our philosophy was that you should teach individual engineers em..individually because you could do all the examples and and make it relevant to their own subjects you see, and you can't do that easily when you have a mixture of engineers er..so we have to sacrifice that a little bit*

.....

but the more overriding problem of the present time was this split of the A levels and the BTEC students because we thought that would be advisable to teach the students that way and (inaudible) to and give them better teaching and so it always compromises, we're compromised er..teaching a group of 2 different a..2 different kinds of engineers into in fact teaching them with the same background really that's what it comes down to and in (inaudible) I'm afraid it comes down to money

because at times because the Engineering Department don't want to give us more because they inevitably there are more new things coming into their own subjects and they want to teach and so again we compromise what what do we want to teach them....."

The teaching philosophy developed for the teaching of Mathematics to Engineers (*vide infra* 2.2) stipulated that students should be taught within their own Engineering discipline. In the special course, the class was made up of all the BTEC entrants from the various Engineering departments. Only a small number of the students were with other non-GCE A level qualifications. This was the compromise that Dr. C referred to. What were the effects, if any, of having a mixed group of students would be discussed in section 4.5.

4.3.4 The need to increase entry to Engineering degree courses.

It was interesting to note that some of the lecturers thought that future intake of BTEC qualified entrants would be increased. At present, there are many efforts to widen access to an Engineering degree course in Britain. Students with various non-GCE A level qualifications are encouraged to apply to come onto the courses. The various non-GCE A level programmes available are BTEC courses, ACCESS courses, Foundation courses, or special link programmes that certain universities have set up with particular colleges. From among these, BTEC qualifications (or formerly students with ONC/OND and HNC/HND qualifications) have traditionally been accepted as the main group of non-GCE A level qualified entrants most likely to take up Engineering degrees at universities or polytechnics.

Dr. B had linked the need to increase BTEC qualified entrants to the general necessity of increasing entry to the Engineering courses. He was also involved at the time in setting up a Foundation course at LUT. In his interview, he said,

(Extracts from interview, Dr. B, 26/6/90)

"Now a number of universities have been facing similar problems they have been worrying about the fact that they are going to have to take in more students with that kind of background in mathematics if not worse, in particular some students whose A levels were not mathematically or scientifically based and perhaps now wish to try a career in Engineering so several universities starting about three years ago set up what we call Foundation years, the idea being to provide a bridge between the experience of the candidate and what we would normally expect to have achieve by A level standards and in that regard the foundation year would fill in Mathematics, Physics, Chemistry and perhaps basic Engineering Science. The scheme being proposed at Loughborough is that the students will be admitted onto existing undergraduate courses with the proviso that they will have to take this foundation year and take particular aspects of it as the department decided and achieve a satisfactory standard before embarking upon the three year course proper."

Mr. K said that both he and Dr. B were members of the Engineering Board working party on student recruitment. Mr. K mentioned that one of the areas that the party had been working on was to attract more students from the non-traditional background. However he felt that,

(Extracts from interview, Mr. K, 15/10/90)

"if we are going to increase the number of people entering in education entering Engineering so it's all those like the BTEC students where we are going to get the extra people from. I don't think we are going to get vast numbers of more students from the conventional A level type of studies, we are going to get them from other areas whether that's BTEC or ACCESS courses or whatever"

The Manufacturing Engineering Department were also hoping to increase their students intake and were looking at various alternatives. It was the only Engineering department in the

University which used the UCCA clearing scheme whereby students who were unplaced could try for placements. A small number of students was also expected to come from the Foundation course to be implemented as it would prepare students for courses in Applied Sciences and Engineering. The Department had at that time began discussions with Sandwell College in Birmingham to set up courses which would linked students on the HNC BTEC courses to degree courses in the Department. Under the scheme, students would be following their BTEC courses at Sandwell, upon a suitable achievement at HNC level, they would be allowed to come into the degree course at LUT at year 2. However if they cannot cope they would be able to continue at Sandwell in a HND course.

4.3.5 Summary

There appeared to be considerable agreement among the interviewees on what were the reasons for the weaker Mathematics background of the BTEC students. The course was enthusiastically supported by the various Engineering Departments as a much needed support to help these students. The course was supposedly designed to allow these students to go through the same first year syllabus with extra time. It was thought that the extra time would be required to enable the students to go through background topics that were not included in the syllabus but would be necessary to the course.

Only Mr. D had some reservations about the practicability of teaching such a varied group of students and of putting the Electrical and Electronics Engineering students in the same group. It would seem that though some the problems of such a varied group was anticipated, other factors, such as giving the students extra time with the Mathematics and that no extra staff was to be involved, were considered more important. Mrs. A was very certain that the students were to sit for a common examination paper at the end of the year, though Mr. D was just as convinced that he would set his own examination for his students, including those that he assumed would come back to him from Mrs. A's class.

4.4 Observational Study of the Mathematics provision: 2nd October 1990 to 31st June 1991

4.4.1 Introduction

The provision was set up apparently to resolve the problems of students diagnosed as having weaker background in Mathematics upon entry. It appeared from the interviews conducted by the researcher with staff, that various concerned lecturers in the Mathematical Sciences and Engineering Departments had held informal discussions about the problem. The main figure in enabling the course to proceed was Dr. B. However, Mrs. A was given the responsibility to teach the course and had designed the teaching of the syllabus. The following accounts of the encounters between Mrs. A and her students will chart the progress of the course. It is also hoped that the accounts will show the influences on the course development and the various adjustments that Mrs. A had to make during the year. It will also show how the students responded to Mrs. A's teaching methods.

A pre-course interview suggested that Mrs. A would implement an innovative method in teaching the students for this provision. She felt that her new method could help to surmount the problem of the varied educational background and work experience that the students had. From her past experience, she had found that some students would need a lot of help with the foundation topics, some would be quite competent and there would others who needed practice with their mathematical skills. She felt that the competent students would become bored if too much of the background work was repeated. She would project the same assumptions to the present group of students. Another objective was to encourage the students to develop self-learning skills as opposed to fed-learning. Her teaching method would consist of six main components as follows:

(1) Text

The book used would be K.A. Stroud "Engineering Mathematics", Programmes and Problems, 3rd edition, Macmillan. Most of the syllabus would be covered by the book. Mrs. A's lecture notes

would supplement any part of the syllabus that was not in the book.

(2) Worksheets

These would be distributed at the start of each new topic. It would include the syllabus, the knowledge and skills to be acquired and the relevant applications for the particular topic. The scheme of work would also be given with details of the lectures, laboratory sessions and/or problem classes that the students should attend. The relevant programmes from the textbook would be included with some questions for the students' self-assessment. Suggestions of other resources, other text or software, would sometimes be given.

(3) Lectures

Mrs. A expected the students to cover the basics of any particular topic from the book at their own pace and only as much as they required. In her lectures, she would concentrate on giving an overview of the topics and presenting the students with a variety of examples including some harder ones. She would conduct some problem classes specifically to present students with harder problems. If the topic were not covered in the text, lecture notes would be given either written on the board or as handouts.

(4) Laboratory sessions

These would be held in the BBC Micro Lab that could only take about 30 students, maximum, as there was only 15 BBC Micro-computers. Mrs. A would hold a few of these session specially in the first term whereby the students could explore some of the topics with the software that she had written. She would organise the session by dividing the students into two groups. Each group would come to the appointed session. The students would join either groups voluntarily.

(5) Tutorials

In these sessions, students would be encouraged to inform Mrs. A of their difficulties in Mathematics, though she would discuss

issues relevant to the students study skills and learning. She would asked the students about their difficulties and would solve problems for the students, sometimes on the board, and sometimes only for the student(s) who had asked. She would try to give some personal attention to all the students present.

(6) Assessment

The end of year examination were the only assessment that was considered by the various Engineering Departments. Mrs. A would hold a mid-sessional test. It was mainly planned as a self-assessment exercise for the students and was portrayed as such. In the event, only the Manufacturing Department requested for the mid-sessional test marks.

The following accounts will show how Mrs. A attempted to familiarise the students with her teaching methods and some of the students response to the methods.

There were also subsequent factors that disturbed the smooth running of the course as planned by Mrs. A. However some of these factors were beyond her control. As an example, the whole course was designed based on the students using a programmed learning text. Thus, the book appeared integral to the smooth running of the lectures and the students' work schedule. However, the book was not available from the book shop until late into the second week. She had encountered difficulties early in the term in confirming the tutorial time slots which resulted in one group missing a tutorial. The students themselves were unsure in which class they were supposed to be and for the first two weeks, the number of students in the class was variable. Coupled to that was the fact that Mrs. A did not have a name list of the students who were supposed to be in her class. One of the difficulties which became apparent was the fact that the students who came in later did not at first understand the teaching method implemented by Mrs. A.

The researcher had attended most of the Mathematics teaching sessions of the students for the academic year. Her research roles during this period depended very much on the situations and their

suitability for the occasions under study. As she had decided to conduct the research openly (*vide supra* 3.4.3), her presence and the reasons she was there was made known to the students. Usually, she was a passive observer during the lectures but participated more as an unofficial assistant tutor during the tutorials.

The academic year was divided into the Autumn, Spring and Summer terms. The corresponding teaching periods were of ten weeks' duration for Autumn and Spring and was of five weeks' duration for the Summer. In the Autumn and Spring terms, the Mathematics teaching sessions were made up of lectures, tutorials and 'surgery'. 'Surgery' referred to sessions for individual students to consult Mrs. A. These sessions were optional, they could be set by appointment or students could go along to see Mrs. A at the appointed times for the different Engineering groups. The time-tabled contact hours were 5 hours a week. This was divided into 3 hours for lectures, 1 hour for tutorials and 1 hour for surgery. The 3 hours lecture sessions were sometimes made up of 2 hours lectures and 1 hour problem class. For the tutorial sessions, the students were divided according to their Engineering disciplines. However as some course groups were very small, the tutorial groups sometimes consisted of combined course groups. The groupings changed a little in the Spring and Summer sessions. The various tutorial groups for the different terms and the list of abbreviations for the course designations will be shown in Section 4.10. In the Summer term, there was some major changes to the lecturing scheme. These will be described in the relevant sections to follow.

The volume of data collected for the year would made it impossible to be presented in full. In all the researcher had attended 52 hours of lectures and problem classes. The total number of hours designated for lectures and problem classes for the years was 75 hours. She had attended 57 hours of tutorials out of a possible total of 113 hours taking into account Bank Holidays and certain special occurrences such as weeks off for the Electrical Engineering students and weeks out for the Manufacturing Engineering students for Engineering Applications. Numerous interviews and conversation cum discussions were conducted during these periods with the students and Mrs. A.

Accounts of the interviews with other lecturers and Admissions tutors have been presented in the preceding sections (*vide supra* 4.3).

In the following sections, the researcher had to choose the data to be presented. The data has been taken from her case records which had been written out more fully after the events based on her field notes. The following sections will convey the mundane and typical of the everyday situations as the year progressed as well as highlighting certain events that had some influence upon the smooth running of the provision throughout the year. In order to do this, extracts from fieldnotes are included, together with typical and representative comments and views of the students. The selected comments and views are presented as a parsimonious distillation of the case data collected by the researcher by observing lectures and tutorials, from arranged interviews with students, from comments made by the students in lectures and tutorials, from overheard conversations between students themselves, from conversations between the researcher and students and from conversations between Mrs. A and the researcher.

4.4.2 The Observations

The first 3 weeks were very difficult for students and lecturer as they tried to organise their time-table. The researcher will include much of the case records relevant to these three weeks since it is felt that the descriptions will show the difficulties encountered by Mrs. A in organising her schedule for the class and confirming the time slots for her lectures and tutorials. Importantly, Mrs. A also had difficulty in determining who were supposed to be in her class.

4.4.2.1 Autumn term, 1/10/90 - 7/12/90

Week 1, 1/10 - 5/10/90

(Extracts from fieldnotes, Tuesday, 2/10/90, lecture, 9.00am, R008)
This was the first lecture and the first meeting for Mrs. A and her students. When the researcher arrived, Mrs. A was already

in the class. Mrs. A did not say anything to any of the students who were already in the class but busied herself with checking the various piles of hand outs. Some Chinese students talked to the researcher having guessed that she was Malaysian. They were from Singapore and they introduced her to a Malaysian student. At 9.00am promptly, Mrs. A started the lecture.

This set the pattern for Mrs. A's classes, she was always very punctual. The lecture theatre had only one door at the front for entry and exit. Another door at the back connected it to the next theatre. The seats were in long rows with aisles running up both sides of the room. The lecturers table was up front, in the middle with the overhead projector to the left. The only windows were at the rear and they were quite small.

(Extracts from fieldnotes, Tuesday, 2/10/90, lecture, 9.00am)

Mrs. A's voice was very hoarse, she apologised for the reduced volume as she had a sore throat. It was difficult to hear her at the back of the theatre. The researcher was sitting in the second row from the back. There was still some general background noise of students chatting. She went into the explanations of the nature of the class giving the reasons for the split from the main group and how it was made up of students from the different course groups. She identified the departments that were supposed to be present. She went on to check the time-tables to confirm the lectures, tutorials and surgery sessions. The class became quite noisy as there were students who were not sure of their time-tables and their department designations. They were from the Electro-Mechanical Engineering course and there were others on other courses from the Electrical Engineering department. She handed out the first year Mathematics syllabus and described it as foundation work. It was 9.15am, some students were still coming in. As they come in they would be looking for seats and sometimes have to cross in front or behind Mrs. A to get to the aisle on Mrs. A's left. She showed the students a copy of the textbook that she would be using. She explained why the book was called a programmed text and how it was to be used.

A student raised a query, he was not sure whether he was in the right class. Mrs. A repeated briefly about who should be in the class. Another asked if the same textbook was being used by the other groups. The answer was in the negative. The time was 9.25am, the students became quieter as Mrs. A described some general teaching methods and her own in particular. She then handed out her scheme of work for the week. She told them that she would hand out schemes of work that would inform them which topics would be taught, the relevant sections in the text to be read, when the lectures and problem classes will be and which exercises should be tried out.

She then talked of the assessment methods of the university and reminded the students that there would be little testing and they should move from 'fed' to 'self' learning. The end of year examinations were progress examinations (to allow them to proceed to second year). She handed out the students record sheets which she had designed. They were for the students to fill in order to record and enabled them to keep track of their work. She said that she would be collecting the sheets at half-term as it would help her in finding out which materials were found useful by the students but they will be returned. She advised the students that they needed to work constantly at Mathematics rather than leaving it and trying to make up later.

There were some questions about the time arrangements and again, a different student raised the question if he was in the right class. Mrs. A answered the questions as she did earlier. At the end of the session, she introduced the researcher to the class and gave her about 10 minutes to address the class.

The researcher introduced herself and explained the aims of the research she was conducting, the methods that was to be used and asked for the students permission to observe them.

The researcher felt that she would like to be able to interview the students within the first few weeks of their entry to the University. This would allow the researcher to record the views of the students while they were still new to university life. She decided to hand out interview request forms which students could fill in if they agreed to be interviewed. She did plan to hand out questionnaires on the students' work experience and educational background focusing on their Mathematics qualifications. However she decided that she would try other means of getting this information first thus the questionnaires were not given out. Mrs. A was aware of her plans. She thought that Mrs. A would have had these information given to her by the various departments.

The researcher was given a lift back to her office by Mrs. A. Their offices were in the same building.

(Extracts from fieldnotes, Tuesday, 2/10/90, 10.00am)

In the car, Mrs. A said that she thought the students were good this morning. She was worried about the time-table clashes, referring to the students' tutorials allocations. Mrs. A asked about the questionnaires as she felt that it would have been the fastest way to get the information and she would also like to know about the students background in Mathematics. Mrs. A will be having another session with the students at 12.00noon.

The researcher then realised that Mrs. A did not have the background information on the students. Mrs. A thought that the information ought to be obtainable from the various departments. Just before Mrs. A and the researcher were going to the next lecture, Mrs. A told her that she has received the time-tables from the various departments but was worried about the absence of Mechanical and Civil Engineering students. She did not receive the students name lists from any of the departments.

Tuesday, 2/10/90, Lecture, 12.00 noon, room S004

The class was in another lecture theatre similarly designed as R008 but with two doors situated at the front for entry and exit. There were some small windows at the back. Mrs. A gave her first lecture to the class.

(Extracts from fieldnotes, Tuesday, 2/10/90, 12.00noon)

> Some students were still talking when she started. She told the students that they were no tutorials this week but that there will be a Problem Class on Friday. She also told the students that there was no need to copy notes as what she was going to teach could be found in the textbook. They were reminded that they should get the book as soon as possible. The researcher could see that some students appeared to have already got the book as they had brought the books into the class. As Mrs. A was teaching, many students were taking down notes. The class was very attentive. Mrs. A was presenting students with an overview of Number Systems and Complex Numbers. She finished the class at 12.50pm, right on time.

The class was predominantly male with only one female student. One of the students approached the researcher, and asked her which course was she on. She explained the reason for her presence. The student was not present in the morning class.

The researcher came back to her office with Mrs. A. in the car, Mrs. A was in good spirits, she felt that the students were very good. She also mentioned that she had always preferred to give an overview of a topic first so that the students would not be victim to being unable 'to see the wood for the trees'. She felt that many lecturers would not use this approach and would go straight into a topic. She felt

that the students would not be able to see the reason for doing a topic and might end up thinking that the skills they were learning were the 'be all and end all' of the course.

Friday, 5/10/90, 9.00am, room S004.

(Extracts from fieldnotes, Friday, 5/10/90, lecture, 9.00am)

> The researcher came in at 8.55am. She chose to sit at the back of the class, second row from the back, on the right. Mrs. A was already in the class. At 9.00am, she promptly began the teaching session. Mrs. A asked the students if they have bought their textbook yet. At her request, students were to raise their hands to indicate if they have not bought the book yet. A majority of hands went up. They were asked to get their copies soon. She told the students that she was having some problems in sorting out the tutorial times. She would let them know by Tuesday.
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> .....
>
> The researcher talked to one of the students as he was wondering out loud why Mrs. A was not teaching the theory but going through the problems. She asked him if he was in on Tuesday. He replied that he was not. He claimed that in his time-table, Tuesdays was for problem classes and Fridays was for lectures. He had missed Mrs. A's explanations on how she was going to teach them. Then a student sitting behind the researcher asked her about the last problem that Mrs. A was doing. She explained it to him. The class had ended.

Some of the students who did not have the text book appeared not to have been able to follow the class.

The first week of lectures was very unsettled. Most of the students did not have the text books. The books were not available at the book store on campus. Several trips were made by the researcher to the book shop during the week but the books have not arrived. The tutorial time-slots were also not confirmed. Mrs. A promised the students that she will confirm the time with them on Tuesday. However in the time-table there should be a group slotted in on Monday afternoon. It seemed probable that this group would have to miss their tutorial.

Mrs. A did not receive name lists from any of the department, thus she did not know which students were supposed to be in her class. She had passed a piece of paper down for the students to put down

their names and their course designations. During that session, there was a lot of noise, some students were not even sure of the correct designation of their course and to which department they belong. These were mainly students on the Electro-Mechanical Power Engineering as the course was jointly sponsored by the Electrical and Mechanical Engineering Departments. The number of students in the class on Tuesday was smaller than that on Friday. The students themselves were not sure if they were in the right class especially those with non-GCE A level qualifications other than BTEC. Students with BTEC HNC/HND (usually level IV and V) were not very clear of their position as well. There were also some students missing, those from the Civil Engineering Department and some who came from the Electrical Engineering Departments who were not too sure of where they were supposed to be.

Week 2, 9/10 - 12/10/90

Tuesday, 9/10/90, Lecture, 9.00am, R008

(Extracts from fieldnotes, Tuesday, 9/10/90, lecture, 9.00am)

> The researcher was in the class at 8.55am. She sat next to an Indian boy and struck up a conversation with him. Mrs. A came in just before 9.00am. She immediately handed out the scheme of work for this week. She told the students that there was some difficulties with the time-table and asked if they was any new students in the class, those who were not in the first week. Some students raised their hands, they were mainly from the Civil Engineering Department. Mrs. A welcomed the new students and explained briefly about her method for teaching the class and the reasons for the mixed class.

Mrs. A had found out from Dr. B that they have had an inception week.

(Extracts from fieldnotes, Tuesday, 9/10/90, 9.00am)

> There were still some confusion among the students as to which class they should be in. A student who said that he had HND asked if he was in the right class. Mrs. A said that he could attend either class if he wished. She then explained about the week's work scheme. She said that the students should use it as a check-list, she had given some keywords and that they were to check which of the topics were known to them. They were supposed to spend more time on topics not known or have been forgotten.

Mrs. A apologises for the difficulty in getting the textbooks. She explained that she had ordered the books since June but for some unknown reason the bookshop still has not stocked the books.

A student said that the A level group seemed to have more classes. Mrs. A replied that this group was supposed to have five hours time-tabled as compared to four for the A level group. She promised that she will look into the matter. It was not obvious from some of the students time-table that they had an extra hour. The researcher had leaned over to look at a time-table but unfortunately did not note which department the students came from. She also reminded the students that they had an option to attend the other class if they wished but they should discussed it first with their course tutors.

Tuesday, 9/10/90, lecture, 12.00 noon, S004

(Extracts from fieldnotes, Tuesday, 9/10/90)

Mrs. A started the session with sorting out the times for tutorials and surgeries. There was still some confusion about the times. However the students were reminded that they should turn up for the tutorials.

Tuesday, 9/10/90, surgery, 2.20 pm, room N223, EL/ECS/EMPE

The surgery was held in one of the lecture rooms in the Haslegrave Building which was where Mrs. A and the researcher had their offices. The researcher came in late as she had a student interview just before the class.

(Extracts from fieldnotes, Tuesday, 9/10/90, 2.00pm)

There were 8 students present. Mrs. A was showing them some software that she had. She asked them if they had any questions.

A student asked about the examination questions, will they be fresh questions or will they be from the past year examination papers. Mrs. A replied that it was impossible to produce original questions every time but standards will be maintained. They were asked to look at past year papers and that they should get copies for themselves. Mrs. A asked if any student felt that he was in the wrong group. One student was not sure as he had done A levels but did not finish the course and had decided to take up HNC instead. He also said that he had worked with BBC computers for 8 years. Some of the students were saying that they had used the BBC microcomputer but they were some who had not. One of the student was filling a form while all this discussion was taking place. Mrs. A asked if they had any problem as they could go otherwise. She reminded them that they should be in on Thursday for the tutorial. Some discussions on the textbooks being used followed.

The students were comparing Stroud to the Bajpai, Mustoe & Walker textbook used by the A level group.

Mrs. A then repeated that they would have tutorial on Thursday and they should come along if they have any problem. Even if they do not have the textbook yet, they should still come as she will be doing some problems. 1 student left but the others stayed as they had some problems to ask. The students had question on some of the Complex numbers exercises from Stroud.

After the class, Mrs. A commented to the researcher that the class seemed to be very responsive and mature in their attitude. The researcher also felt that the students appeared to be quite confident of themselves.

Wednesday, 10/10/90, tutorial, room S174, MECH/EMPE

(Extracts from fieldnotes, Wednesday, 10/10/90)

When the researcher came there was only one student in the room. At 9.00am, there were 13 students present.

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A student asked about the examinations, whether it will only be at the end of the year. Mrs. A replied that there might be a mid-sessional test but that only the final examinations will count towards progress to the second year. Another student asked about the length of the examinations. She said that it was three hours' long and also asked them to look up past year examination papers, form their own department and from the other departments as well. She said that in the past, each lecturer set his own questions but because this group was combined, the questions might be different as she will be setting them. It was nearly time to go.

After class, two students came up to Mrs. A asking whether they could change classes, they were the two with the difficult names. One said that he had done the International Baccalaureate and the other said that he has done Part 1 and Part 2 of something, both Mrs. A and the researcher could not understand what he said (the researcher found out later that he had done a course at his local university before coming to UK). Mrs. A drew the researcher into the discussion and asked if she knew how the International Baccalaureate was rated. She thought it would be considered comparable to the GCE A levels. The boy with the Part 1 and 2 was insistent that he would like to change classes. Mrs. A asked him if he had tried any of the exercises. He said that he had. She asked if he had the book, he replied that he did not. Mrs. A said that he should discussed his case with his course tutor (both of the students did change over to the main group and they did not come to Mrs. A's class after that).

The researcher left with Mrs. A. Once outside the building she asked Mrs. A about the exercises in the book which the students had described as 'jumping a level'. Mrs. A said that she thought that the students had to be adaptable, able to pick and choose the Mathematics as they needed as this was how it would be in real life. She did realise that the students have just heard about scalar product but she thought that it was a good example to show how vectors could be used.

While discussing the students, Mrs. A told the researcher of a student who had told to her that he could do all the test questions in Stroud but when Stroud 'jumps a level', they would be harder to answer. He had wanted Mrs. A to recommend a simple A level book for him to practise on. Mrs. A said that she told him that he should try the harder problems as his ability to do the test questions showed that he had the basic skills to attempt the problems. She commented that the A level students might have problems with the same questions. She felt that some of the students were putting themselves down though there were some who thought they were too advanced for the class. She then said that as the two boys (referring to the boys who had requested to change classes) did not have the books, she could not be sure that they had done any work.

Thursday, 11/10, tutorial, 12.00 noon, EL/ECS, T247

The researcher used the tutorial sessions to be able to get to know the students as they were usually in smaller groups. It would be easier to remember faces and names. Mrs. A started of the session by asking the students if they had any specific questions. Some of the students left.

Week 3, 16/10-19/10/90

Tuesday, 16/10, lecture, 9.00am, R008

(Extracts from fieldnotes, Tuesday, 16/10/90, 9.00am)
Mrs. A had to pass another sheet of paper round the class asking students to write down their names. She explained that

it was to update her old list as well as for her to find out if she needed a bigger theatre. The room seemed too full during previous lectures. The seats were in long rows so it would be difficult for latecomers to occupy the seats in the middle even if they were vacant. Students would move along for the others but they were some who did not, so the latecomers had to find chairs and sit on the aisle on either side of the room or in front.

After the class the researcher went over to talk to a student who had agreed to be interviewed. An interview date was agreed. Another student signalled to her and she walked over to him. He, too wanted to set an interview time and date. He was a Malaysian student. She told him that any time convenient to him would be all right. He said that he was free then and she said that they could do the interview in her room. Mrs. A offered them a ride in her car back to the office.

Tuesday, 16/10/90, lecture, 12.00 noon, S004

The lecture was on Partial Fractions. Mrs. A conducted it as she does typically, starting off with an explanation of the terms used and then proceeded to show how to derive the Partial Fractions. Some of the students were constantly talking among themselves. The researcher noticed that those near her were discussing the examples that Mrs. A had put on the screen.

Wednesday, 17/10/90, Tutorial, 9.00 am, MECH/EMPE, S104

9 students were present for the tutorial. Mrs. A asked the students if they had any problems related to the mathematical topics they had covered in the previous lectures. It was a typical tutorial sessions in which Mrs. A would solve any problems that the students had raised. However, she would work out the problems, while giving advice on how to start off on the problems and how to sort any information given in the questions. The researcher noted that only a few students participated during the session. The students appeared to be worried about the mid-sessional test and wanted to know more about the sort of questions that were usually asked.

Thursday, 18/10/90, tutorial, 10.00am, DME/EME, GG101

The session was well attended. 14 students were present although a few came late. The students were more lively and participated in the discussions. Some came well prepared for the sessions, with ready questions on the problems and on the topics already taught. Those who did not have any question, used the time to go through the textbook and their notes.

Thursday, 18/10/90, tutorial, 12.00 noon, EL/ECS, T247

A student, Billy came up to the researcher to apologise for not turning up for his interview. Another time was set for it. There were 5 students present, Jill, Tom, Mark, Billy and Rick. It became clear during the tutorial that Jill, Tom and Mark were up to date with their work. They asked most of the questions while the other two students just listened in and copied the solutions that Mrs. A put up on the board. One of the students, Billy, did not even have the right tutorial sheets.

Friday, Problem Class, 19/10/90, 9.00 am, S004

Mrs. A had decided that she would use the session to go around the class to help students with any problems related to the programmes they have covered so far in the textbook. Many of the students left the class leaving only 12 students. The researcher used the opportunity to talk to some of the students especially a group of Civil Engineering students whom she was not acquainted with.

(Extracts from fieldnotes, Friday, 19/10/90)

> The researcher then walked over to a group of Civil Engineering students sitting in the middle of the rows. She asked if they mind being interviewed. They said no. So she took their names and term-time addresses. She asked them how they were coping as they had missed the first week. Mick said that he has done Complex numbers but has never done Vectors before. He had only done a little but found that the notes made no sense. He found the book a help. He said that he had done the BTEC course sometime ago and had not done Mathematics for sometime. He then asked a question on Partial

Fractions. They discussed the question with another student, Edward joining in. Edward is Singaporean. He had told the researcher that he only had O level Mathematics and that he did not do Additional Mathematics at O level. He claimed that he did not do any Mathematics in his Building Course at a Singapore Polytechnic. She asked him how he was coping and he said that he had been going through the book. The conversation then drifted onto some general topic.

Friday, 19/10/90, tutorial, 10.00 am, CIV

(Extracts from fieldnotes, Friday, 19/10/90, 10.00am)

Mrs. A had to sort out the tutorial time-tabling with the students. It seemed that a Computer class was slotted for them in the same period. Mrs. A said that it was the Civil Engineering Department that gave the time slot. The students however said that the time was fine by them. Mrs. A then checked the students attendance. As usual she asked if they had any problems with their programmes. Some of the students asked her to solve some Vector problems. They were the same questions that she had solved for the earlier tutorial classes.

The researcher found out later from the students that the Civil Engineering Department had slotted a 2 hour Computing class in the same time slot as the Mathematics tutorial. This meant that the students usually missed the first hour of the Computing class. They said that they preferred coming to the Mathematics tutorial as they had done some Computing before.

Week 4, 22/10/90 - 26/10/90

The case records for the Monday tutorial group is presented here as this was the first time the researcher was attending the group's tutorial session. She had missed the third week's tutorial as she had been conducting a student interview during the same time. It is included as it would introduce the students who were in this group. Later developments on the relationship between Mrs. A and the group proved interesting. Mrs. A had reasonably good relationship with students who were in the other tutorial groups, at least with the students who did attend the tutorial sessions. However, the rapport was missing with this particular group. Mrs. A was not sure why this happened. There were times when the students were totally unresponsive to Mrs. A.

Monday, 22/10/90, tutorial, 2.00 pm, MME, JJ011

(Extracts from fieldnotes, Monday, 22/10/90)

The researcher was late and when she arrived, Mrs. A was already in the class. She was reviewing the work that should have been done on Matrices. She then asked if anyone wanted help with Partial Fractions. No one did. She then asked if they were reasonably happy with it. She looked at the students and said: "you're all right with that, good", she must have seen some indication of agreement as the students were silent.

She asked about determinants - no response. She then said that in the book, there's something called Cramer's Rule and illustrated it on the blackboard.

Some students were talking. She asked if they have met Cramer's Rule as written on the board. Someone answered, "yes". She asked, "Has anyone met Cramer's Rule any other way?" No response. Mrs. A said "sometime you might meet Cramer's Rule in a different way" and proceeded to illustrate it. "If they have met it, it's a good idea to look at the programme containing it."

She then asked if anyone has tried it? "How many haven't tried it?" A few hands went up. She said, "it's a good idea then for them to try a few now". Students were looking at the problems - a lot of discussion taking place.

She asked them "what page was it on?" No one answered. She found it herself, p116 (she said the page number out loud)
Most students were trying to do the problems Mrs. A suggested. 2 students were doing something else.

The researcher attended the lecture on Tuesday morning and observed that Mrs. A had maintained the same routine. She had handed out the work schedule for the week. For the past three weeks, the work schedule had been weekly. However, in her programme for the year, there would be some topics which would take up more than one week. She would lecture and write down the notes, her pace would usually be moderate (in the researcher's view) though she would slow down if the students requested it. For the afternoon sessions, she would be demonstrating a programme called CONIC. She asked how many students would be interested and only about half the class put up their hands.

The researcher did not attend any of the sessions for the rest of the week, using the time to look through her notes, sifting through the data accumulated and making initial attempts to code the data.

The slots for the groups contact time with Mrs. A has already been settled. The routine was already part of the students weekly schedule. Lectures would be given on Tuesday mornings, afternoons and Friday mornings. Mrs. A sometime conducted Laboratory sessions and Problem Classes on Tuesday afternoons and Friday mornings. The weekly schedule or the schedule for the programme to be taught would be given on Tuesday morning.

During this time, the researcher had also been conducting interviews with the students and members of staff as and when they requested. The accounts on the students interview will be given in Section 4.6.

In the following accounts, the researcher will present certain events from the case records that had some influence on the development of the provision.

Week 5, Tuesday, 30/10/90, Lecture, 9.00 am, R008

(Extracts from fieldnotes, Tuesday, 30/10/90, 9.00am)

> As the researcher came in, looking for a seat, she saw Ari and Matt2 and went up to sit near them. Matt2 expressed his dissatisfaction with Mrs. A's lectures to her without any prompting. Ari also joined in the conversations. Their complaints (Matt2 was doing the complaining but Ari voiced his agreement) were about the notes: gaps in the solution which was difficult to fill in later.
>
> They said that they were working hard at Mathematics for the last couple of weeks to catch up. They said that the A level students were behind them in the Mathematics topics. Mark claimed that he had to go the surgery to fill in his notes.

His frustrations with the Mathematics course was apparent. Later, in a conversation with Mrs. A about Matt2, it came out that Matt2 has been in surgery a couple of times asking about his notes. Mrs. A felt that he should have used these sessions for discussions about his work.

(Extracts from fieldnotes, Tuesday, 30/10/90)

> While talking to some students, the researcher found out that the Manufacturing and Electrical students would be having

week 6 off. The Manufacturing students would have an Engineering Applications week while the Electrical students were to have a reading week.

Mrs. A came in with work schemes for weeks 5-7 and gave some explanations on the work expected. As she was explaining, a student raised the issue of their having week 6 off. Andy2 said that the Electrical students would have week 6 off as well. Mrs. A said that she'll have a good time with the Mechanicals and Civils. She said that she might have to double up some lectures for the people who missed the lectures in week 6.

It appeared that Mrs. A did not know about the students having week 6 off. Later, in a discussion, she claimed that she knew the Manufacturing students would have an Engineering Applications week but she was not told in which particular week it would be held. It was the same with the Electrical Engineering students. It should be noted that in the past, Mrs. A had been teaching mainly Mechanical Engineering students.

(Extracts from fieldnotes, Tuesday, 30/10/90)

Mrs. A continued with the explanations on the work scheme. She gave them a reminder that some of the students have not been using their time sensibly. She said some of the students seemed to work only while she was in the room. She said that they had to work quite a lot in between. Mrs. A then said that it was time to start the lectures.

There was a sudden eruption of noise from the student as a flurry of activities, taking out pens ((and paper)) took place. Mrs. A said that students were to sit back and listen and if they took notes it would only be a line. As she started, the class quietened down, and looked attentive. She then put up some notes which the students started copying.

.....

The researcher walked out with Paul and Ben. She asked them how they were getting on with the course. Ben asked what she thought of the pace of the lectures, whether it was too fast or too slow. She said that she thought the pace was fast especially on vectors. If someone had not done it before, one week was not enough. He said that he thought it was too fast as well but he's hanging on. Paul then said that it's all the lectures, everybody going fast. The researcher asked Ben, "How's the mechanics?" Ben said that it was okay but felt that what Mrs. A did in the lecture could have helped them before, in particular the topic on area under the curves. Then he said, "but the maths is being used too quickly in other subjects, for instance, in vectors, what she was teaching in the morning, they were using in electromagnetism, the lecturer was going on about dot products and this and that".

During the afternoon class, Mrs. A announced some adjustments that she had made to the work schedule for week 6. This was to take into consideration that some of the students would not be in during the week. In class, the students would usually be copying the notes that Mrs. A put up on the screen, regardless of her exhortations that most of what she is doing was in the textbook. Mrs. A would indicate quite clearly if the notes she was presenting were not in the book.

In the Wednesday tutorial for the EMPE/MECH students, Mrs. A started off the session checking the attendance. She then would ask if anyone had any questions. Last week the students were not very responsive but this week, they appeared more prepared and were more communicative. A couple of students asked for some explanations on the Trigonometric Identities. This topic was not in the syllabus but was needed to simplify certain answers in the exercises.

During a conversation with her, the researcher found out that Mrs. A was upset with the Monday tutorial group. They had been "most uncooperative" during the tutorial. She said that she was upset as they had come without any preparations and they had not said anything. She found it irritating that they came to tutorials but they had not been to the lectures. There were times when the students did not have the week's work schedule, which implied that they were not in class on the Tuesday mornings when she had passed out the schedules. However the same students were quite talkative to each other but they would not respond to Mrs. A.

On Friday, Mrs. A held a Laboratory session. It was held in the Computer room in N223. The programmes were run on the BBC Micro-computers. The students were quite free to explore the programmes. She walked around the room, making herself available if the students wanted help or had any questions.

Week 6, 5/11 - 9/11/90

In week 6, the attendance for the lectures was understandably smaller. However there were a number of Electrical Engineering

students who attended the lectures as well. One of the boys who attended said that he had to attend Mechanics lectures so he decided to do the Mathematics as well so as to have some time off in week 7. Mrs. A had rearranged her work schedule to incorporate some repeat lectures in week 7 for the benefit of the students who had week 6 off.

In one of the many discussions that the researcher usually had with Mrs. A in a week, she asked Mrs. A if she knew that Mr. D was expecting his students (Electrical Engineering students) to come back to his group for the third term. She said that she did not but thought that it was for the best as she had to teach Statistics for the Manufacturing and Civil students which was not required for the Electrical students. She also said that she thought the final examination paper would be a common one for all the groups. She also told the researcher that it was fortunate that the fallow week came in the middle of the topic on Functions as she had allocated 3 weeks to it. She confirmed that she did not know of week 6 being off for some of the students. She felt that the specific departments should have informed her of their plans.

While looking at the syllabus sheet, the researcher remarked that it was good that she had assigned 2 weeks for Differentiation and 4 weeks for Integration as that would allow the students time to consolidate the materials. Mrs. A said that she might have to squash that so that she could put in Ordinary Differential Equations as well, just in case the Electrical students would be joining Mr. D in the third term. She said that she has not been told officially as yet whether this would be the case.

Week 7, 12-16/11/90

Monday, 12/11/90, tutorial, 2.00pm, MEM

Mrs. A did not receive any response from the group to start with. She introduced a postgraduate Mathematics student to the class who might be taking them for tutorials in the second term. She had come

in to join the class for the tutorial, to see how it was being conducted and what the students were doing in Mathematics. As usual, Mrs. A checked the attendance and asked if they had any questions. From the fieldnotes,

(Extracts from fieldnotes, Monday, 12/11/90)

> Mrs. A told them what topics will be taught for the week and when the lectures will be held. She had assigned a 9.00am lecture and a Lab session at 12.00 noon. Mrs. A asked them if they had any question on any previous topics. One student asked whether there will be a test. Mrs. A said that there will be one next term.
>
> No one said anything. Mrs. A then asked, "what haven't you done?" The students started talking among themselves. Mrs. A asked whether the absence of questions meant that they were having no problem. No response. Students were still talking among themselves, telling each other what they have done but not to her. Mrs. A went through the topics, one by one.
>
> On Complex Numbers, a student said that he could do Stroud's but not Mrs. A's harder problems. She said that's quite all right as the harder problems were chosen specifically because they were hard. On vectors, Mrs. A asked whether they had done vectors. They said that they had done it. She said, "good, that's all I want, some answers, you're behaving quite like a silly class at the moment, not giving any response."
>
> Students became more responsive to Mrs. A's questions. They began to identify the areas they were working on and what they needed help on. Mrs. A made sure that everyone told her what they were doing.

The researcher asked Mrs. A if she felt that she needed help with the class. She said that she did not really but Mr. P (the Administrative Officer) suggested that the postgraduate student could help. Mrs. A was not sure if she was suitable. It was not clear what Mrs. A meant by being suitable. In most of the tutorials classes that the researcher had attended, there were only a small number of students who came. It did not appear as if Mrs. A had needed any help. The students would ask some questions which Mrs. A would do on the board, she would walk around the class, giving each student some personal attention, if required. The students did not usually have many questions to ask, except for a few regular comers. Most would be doing their own work and would only respond if Mrs. A asked them questions.

In the Wednesday tutorial sessions (EMPE/MECH), Mrs. A did some problems but went through the steps fairly slowly with more explanations. Before the class, she was discussing with some of the students about their work. While solving one of the problems, a student asked for a real application for the problem that Mrs. A was working on. It was on parabolas. There had been other incidences in the past weeks when the students had requested real applications to the problems being solved as well as an actual representation of the solution. The students who came were very communicative and made their problems known to Mrs. A.

It became obvious that one of Mrs. A's problems with determining the students needs was the lack of readiness of the students themselves to communicate their problems to her. She was usually very quick to respond to any request from the students to explain any mathematical topic whether it was within the syllabus or not. At this time in the term, the number of regular students attending tutorials was very small. There was a bigger number of students who came irregularly or some who came in once in a while. The only group that had a large attendance was the Monday group. The anomaly in this pattern was that the students in the Monday tutorial group were also the most unresponsive.

During one of the tutorials, the researcher asked some of the students why they came to tutorials without much preparation and sat through the whole session hoping that Mrs. A would solve some problems on the board for them to copy. They said that tutorials was compulsory and one of the boys said that there was an incident when a friend received a letter from the Course Tutor for not attending tutorials. Dan2 related that his method of learning the Mathematics was to go through the programmes once, try a few problems and wait until it was nearer the examination to revise the programmes and the solved problems that Mrs. A had done in class. He said that he had a poor memory retention and needed to study quite near to the examinations. He claimed that this technique had worked for him in the past.

(The researcher did not attend any of the sessions for week 8 as she decided to take sometime off to organise her notes).

Week 9, 26-30/11/90

Tuesday, 27/11/90, lecture, 9.00am, R005

There was a slight confusion for the class in the morning. The students were supposed to have a laboratory session in block N but the room was double booked. The researcher and some of the students had to walk back to R005 which was about fifteen minutes' walk, from block N.

After the lecture, the researcher walked out with Mrs. A. She told her that she had planned the lecture to be in two halves, as she wanted to use a program, but she had forgotten to book the Computer room. It was usually free but it was booked by a different class for that morning. She said, "*All this while, there's been a lot of muddles but it was never my fault but this one is*".

Tuesday, 27/11/90, lecture/laboratory session, 12.00noon, N226

The group that was to come in for the afternoon session were taught in the manner that was originally planned by Mrs. A. She explained about Power Series and showed how the series could be used to approximate some functions. She demonstrated by using her program called TAYLOR. The approximations could be seen clearly from the graphs on the screen. The she gave the students their discs and guide sheets to try the program for themselves.

During the tutorials for the rest of the week, Mrs. A returned the students record sheets which she had taken from the students. The students who came to tutorials usually had some problems that they wanted her to do. These problems could be from any of the topics that they had done. In one of the tutorials, a student was asking questions on Complex Numbers. In the book, Stroud used j for $\sqrt{-1}$ in Complex Numbers. The students too were more familiar with j than i.

At the beginning of term, Mrs. A tended to use i but later she started using j more.

Mrs. A was quite happy with students in the DME/EME tutorial group that she took on Thursdays. These boys were also from the Manufacturing Engineering Department. Mrs. A said that she found the group would have gone through their work and would ask more questions when they were stuck. She said that the Monday group (MEM) rarely had any question because they had not done their work and felt that they probably only did some work during tutorials. The researcher commented that only a few of the boys were like that. She knew of one student who preferred to come and do some work during tutorials in the class, knowing that Mrs. A was there if he needed her. She said that was all right by her but felt that some of the boys were not doing any work even if they were there. She wondered if it was better just to do some problems on the board for them.

Week 10, 3-7/12/90
Monday, 3/12/90, tutorial, 2.00pm, MEM

Some of the students were having examinations this week in some of their Engineering subjects. Mrs. A had also found out that the Manufacturing students would be having the first week of next term for Engineering Applications and the Electrical students would have examinations for that week. This meant that Mrs. A did not actually have 25 weeks for Mathematics for these students. However she was told that Dr. B would be continuing with the Mathematics provision for the BTEC students next year. The researcher asked Mrs. A how this course would be evaluated. She said that it would be difficult as this was the first time the students were put in separate classes for Mathematics.

The lectures went on as usual though attendance to the tutorials were poor. This was the last week for the term. The students would be having a 5 weeks holiday. Mrs. A conducted a problem class for Friday, 7/12/90. Only a third of the students were present.

Some of the students were unhappy with the notes that Mrs. A usually gave in class. They were also unhappy that she did not finish her examples or would just tell them verbally how it was done. They claimed that it was not easy to follow the notes later and to finish the examples by themselves as there would be some steps missing from the example. It appeared that after 10 weeks with Mrs. A, some of the students had forgotten what Mrs. A said about how she would be conducting the lectures. One of the student, Stuart1, said that Mrs. A's lectures was only useful if they had read up the programmes first but she usually gave out the work schedule on the first lecture of the week. Another, Hugh, found that it was not useful to copy any of her examples but it would be better if he just listened as he could not listen and copy at the same time. It appeared that the students were developing their own strategies on how to cope with Mrs. A's style of teaching and their workload.

For example, when the Manufacturing students had their Engineering Applications week, they had to submit written reports and sat for a test based on their work. Most of the students claimed that they put their Mathematics aside in order to do these reports and prepare for the tests first. Among the student respondents that the researcher had befriended, she knew some who worked consistently at Mathematics. They were others who did not do as much work in their Mathematics. Even among those who were consistent, they too had to organise their own work schedule in order to cope with all their work load during the term and sometimes had to prioritise their assignments. It would appear that the ability of the students to organise their study effectively was an important factor in their learning. This would also affect the benefit they derived from attending Mrs. A's lectures, problem classes and tutorials. Mrs. A's concerns that some students were not prepared during the tutorials appeared to be true. These students claimed that they would be working on the Mathematics during the holidays. Some were not up-to-date with the reading of the programmes. They were just copying the notes from the lectures and coming to tutorials to copy the problems that Mrs. A would invariably be solving in class. They felt that these would be useful for revision.

During the early stages of the course, the students displayed an overwhelming concern about the examinations. Among the questions raised were: how many examinations will there be, who would set the questions, what would the questions be like, would the different groups be set the same questions. This preoccupation with obtaining as much information about the examination was evident throughout the year and especially so during the Summer term when Mrs. A spent a lot of a time solving questions from past year examination papers in the tutorials.

4.4.2.2 Spring term, 10 weeks, 7/1/91-15/3/91

The Manufacturing Engineering students were not in for the first week as they had Engineering Applications again. The Electrical Engineering students were not in as well as they had mid-sessional tests. The researcher attended the first lecture but did not attend the rest of the week's sessions. There were some changes to the tutorial sessions as some groups were not able to attend the time as allocated last term. The main group that was affected were the EMPE students who had their tutorial moved to Thursday afternoon at 2.00pm from a joint session with the MECH on Wednesday morning. However the tutorial time was blocked with other subjects where the tutorial was by appointment.

Week 2, 14-18/1/91

Tuesday, 15/1/91, Lecture, 9.00am, R005

Mrs. A had revised the time allocations for the remaining syllabus. It was now confirmed that the Electrical students would be going back to the main group in the Electrical Department for the Summer term as they had to do Vector Calculus. The other students did not need this topic.

(Extracts from the fieldnotes, Tuesday, 15/1/91, lecture, 9.00am)

> The class is full. Mrs. A explained about the revised programmes and the reasons for it. She told the class that the Electrical students would have to do Vector Calculus which was not in the syllabus for the others. She said that since the

lecturers for the different groups were in conference all the time, the students were not to worry about joining the A level group.

In the original programme that she had planned, Mrs. A had allocated 4 weeks for Integration, 2 weeks for Partial Differentiation and 4 weeks for Solving Equations and that would have made up the 10 weeks for the Spring term. Within the revised programme, Mrs. A had to reduce the number of weeks allocated for these topics as she had to include Ordinary Differential Equations. It was originally slotted for 4 weeks in the Summer term. These changes had to be made so as to ensure that the Electrical students would be able to follow the topics to be taught within the A level group when they went back to it. The Mathematics programmes, the original and revised are given in Appendix 6.

Mrs. A's teaching style was the same as last term. She would write notes on the board but when it came to the examples, she would sometimes leave out certain steps but these were described verbally. The researcher was made to understand by Mrs. A that she felt the steps that she had left out were quite obvious and would not affect the understanding of the problems.

In class, the students became more obvious in displaying their restlessness and prone to wisecracking remarks. For example:

(Extracts from fieldnotes, Tuesday, 15/1/91, Problem class, 12.00 noon)
She continued with further examples from programme 18. She did questions 7 and 8. As she got to the end of number 8, the class became more noisy.

She was writing and explaining as she went along. Most of the student were copying and chatting to their friends as the same time. Hugh was only listening and watching Mrs. A. The researcher asked him if he was going to take any notes. He replied. "No, I won't be able to follow if I did".

Some of the students would sigh loudly while she was teaching. When she was solving one of the problems, she said, "Let's stop there" (with reference to the workings). One student said loudly, "Yes, let's stop". This made the other students laugh. They seemed to relax for a moment and started talking to one another.

Mrs. A still had some minor administrative problems as well. For one of the tutorials (Wednesday, 16/1/91, week 2), she found the room allocated to her in the time-table occupied by another class. She found out that the room had not been booked for her and had been booked by the other lecturer. She had to find another room for her group and asked the Administrative Officer to book it.

There were times when there appeared to be a miscommunication between Mrs. A and her students. In the Thursday (17/1/91) tutorial, Matt2 and Peter2 asked to be excused from doing the Mathematics in order to study for their Electronics test after the class. However they wanted to work in the tutorial room. Matt2 and Peter2 were regular students at the tutorial sessions and had usually come prepared for the sessions.

In the afternoon, Mrs. A told the researcher that she was irritated with the tutorial session in the morning. She felt that some of the students were wasting their time and not doing their Mathematics. The researcher informed her of what Matt2 and Peter2 were doing. It was obvious that Mrs. A had not heard the request they had made early in the class.

Mrs. A had given the students a mid-sessional test during the first lecture on Tuesday morning in the third week, 22/1/91. An objective of the test was for the students to assess their knowledge and mathematical skills. Mrs. A had fulfilled this objective by returning the corrected papers as quickly as possible and discussing the questions in the tutorials. The corrected papers were handed out to the students during the tutorials in that week. Quite a few of the students did not attend tutorials and they received their test papers during lectures. They had missed the discussion on the paper.

Mrs. A had to conduct a lecture during the tutorial session on Thursday, 24/1/91 to make up for the lecture that the group missed in the first week.

The researcher had noticed a particular student who had been absent from the lectures and tutorials frequently. He was a Malaysian

student but had entered with pre-University qualifications from USA. When she inquired about him from his friends, they said that he was teaching himself. He later dropped out of the whole course and changed to a different course altogether.

Mrs. A's relationship with the Monday tutorial group was deteriorating as well. In week 3, there were only 2 students present for the session. In week 4, 10 students were present but then Mrs. A was going to return the test papers. The attendance for the group was variable but even if they came, they did not respond to any of Mrs. A's questions unless they were urged to or directly asked by Mrs. A. Their reactions to Mrs. A's comments in class was interesting as they usually responded by laughing even when Mrs. A appeared irritated with their behaviours and said so.

(Extracts from fieldnotes, Monday, week 4, 28/1/91, tutorial, MME.)
Mrs. A: "Why are you such an unresponsive group."
Someone responded and Mrs. A said, "Not hopeless mathematically".
The students laughed.
Dan1: "Being polite?"
Mrs. A: "No, not polite"
They laughed louder still.

Mrs. A was annoyed with the group, not because they had not done their Mathematics but because of their lack of response. A typical Monday session would be Mrs. A asking the class what they would like to do. She would get no reply and she would suggest problems or activity for the afternoon. If she did any problems on the board, they would copy them and if she did not, they would have their books open, some would be reading and others doing some problems. There were some students who would not be doing anything for the whole hour.

On Tuesday (29/1/91) in week 5, Mrs. A received a letter through Dr. B from the Head of the Civil Department. He was concerned that some students were complaining that Mrs. A had cancelled classes, repeated lectures and did not give the students extra time. Mrs. A was understandably upset. The researcher was shown the letter and Mrs. A discussed the problems that had made it necessary to restructure the course. These were the absence of the Electrical and

Manufacturing groups in some of the weeks and the absence of the Civil students in the first week. However she had conducted repeat lectures in tutorial sessions.

(Extracts from the fieldnotes, Tuesday, 29/1/91)

She was surprised at who would be complaining from the group as there were only 7 of them and only 4 attend the tutorials regularly. She felt that she got on well with them. She described what happened last Friday (the researcher did not attend). They had discussed about self-esteem, self-respect, working with better students and trying to catch up without losing self-respect. She commented, "It was a pastoral meeting not just a tutorial".

During the discussion, the subject of Monday group came up.

(Extracts from fieldnotes, Monday, 28/1/91)

Mrs. A said, "I'm sure they were cross with me but they're the only ones I don't like, they don't do any work. I know they're complaining about coursework but there's 1 hour on Monday that they waste every week."

The researcher told Mrs. A that she took 2 students for an interview immediately after last week's tutorial. She said that she knew. The researcher told Mrs. A that the students said that they were not cross but rather embarrassed as they acknowledged Mrs. A's enthusiasm and that they knew she wanted to help them but they have not done the work she was discussing.
Mrs. A replied, "I'm not cross because they've not done the work but because they do not respond."

The researcher had managed to get some time to talk to the regular students in the Civil group. In their conversation, she found out that they had not made any complaints about Mrs. A's teaching though they were worried at the differences in the syllabus between Mrs. A's and Dr. B's class. They also felt forgotten by the Department as they usually missed announcements, handouts and recently forms for the Institute of Civil Engineers as these were usually given out during Mathematics lectures in the A level group.

<u>Wednesday, week 5, 6/2/91, tutorial, MECH.</u>

Only 2 students came for the tutorials. The attendance for this group was quite poor. There were 2 regulars, Tom2 and Peter1 and 1

student who came in once in a while, Niki. The others rarely made an appearance. While waiting for the students, Mrs. A told the researcher that she had sent off a reply to Dr. B. She also told the researcher that she was 'thrown out' of another room that has been allocated to her. It was the room for the Thursday EMPE group. She had used the room for the first 2 weeks but found another class using it in the third week. The room was not booked for Mrs. A and was booked by the other lecturer. She had to look for another room. For that particular occasion, an office which was locked was opened up for her. Mrs. A was upset as she thought that Mr. P must have asked the individual departments to book the rooms for her. She felt that it must have fallen through and no one did anything.

Thursday, 7/2/91.

Mrs. A told the researcher that Mr. P had also rang her up to ask about the arrangement for next term. She told him that she would be doing Statistics and revision for Civil and Manufacturing students, mainly revision for the Mechanical students, although they can do the Statistics and the Electrical students would be going back to the main group. Mr. P said that the departments might not be too happy about that. Mrs. A said that with all the constraints they should not be complaining if she had finished the syllabus. She felt that there was too much interference with her work.

Mrs. A's relationship with the other groups were good especially with the students in the EL group, Tom1, Mark and Jill. They were usually up-to-date with their work, always turn up for tutorials prepared and came regularly. She once described Tom1 and Mark as "my two faithfuls". The ECS students rarely turned up for tutorials. The EMPE students became less regular in the second term but their tutorial hour was blocked with other subjects. Most of the students who did attend the tutorials had questions to ask or were in some difficulties. The only class that did not fit into this mould was the Monday group. The researcher had decided not to attend the Surgery hours. The Surgery session would usually be held in Mrs. A's room unless too many students turn up or would be set by appointment. Thus the

time for the sessions were arbitrary. It would also mostly be one-to-one session. The researcher felt that the students might prefer to have these sessions in private though Mrs. A declared that she did not mind the researcher's presence. However, information gathered from Mrs. A showed that not many of the students took advantage of these sessions. The students who came were usually those who would come to the tutorials as well.

In week 7, Mrs. A received a letter from the Head of the Civil Department which stated that the complaints were cleared up. He wrote saying that it was clear that the events that happened were beyond her control.

Tuesday, 19/2/91, week 7, lecture, 9.00 am.

The researcher was given permission to hand out her questionnaires to the students. The questionnaire was just a data seeking exercise which was to elicit information about the educational background and work experience. Discussions about the questionnaire will be presented in Section 4.8.2.

Up to week 7, Mrs. A had still not given out the students record sheets. These record sheets were for the students to write down what they had read or done for the different topics. When the researcher asked Mrs. A, she said that she had forgotten to hand them out and felt that it was too late then to do so.

In week 10, Mrs. A handed out another set of questionnaires set by the Mathematical Sciences Department. The students were asked to evaluate the Mathematics course they were on. Discussion about this questionnaire will be given is Section 4.8.3.

Mrs. A had found out that the different departments were not having a common paper for the Mathematics as they had set different examination dates for their students. The different departments had organised programmes for practical work for their students. Mrs. A was disappointed as she had prepared with Dr. B and Dr. C, an

examination paper for a common examination. In the end, Dr. B had to set a new paper for the Civil Engineering students. The original paper was taken by the Manufacturing and Mechanical students. The Electrical Students sat for the paper set by Mr. D. Again Mrs. A felt very disappointed because even though Mr. D promised that she could look at his paper, she did not receive it until very late and thus could not make any input on it.

4.4.2.3 Summer Term, 5 weeks, 29/4/91-31/5/91

The Manufacturing students had week out for the first week again. The Mechanical students were not required to do Statistics in the first year as they would have it in their second year syllabus. Thus for the first lecture of the term, only the Civil Engineering students were present. There were only 7 students in this group. Mrs. A had to make major changes to the work scheme due to the changes in the second term. For the Summer term, she had to accommodate the different requirements of the students. The Mechanical Engineering students had their Mathematics reduced to 2 hours a week, with 1 hour on Thursday afternoon for tutorial and a lecture session still maintained on Friday mornings. They had lost the Tuesday morning and afternoon sessions. Mrs. A had rearranged the schedule as such:

> Statistics (Civil & Manufacturing) on Tuesday mornings and afternoons.
> Revision for Friday mornings. She had included the topics for revision in the work sheet.
> Problem classes would be held in the individual group's tutorial slots. The problems were mainly from past year examination papers.

Friday, 10/5/91, week 2.

Mrs. A broke the news to the Civil students that Dr. B would be setting their Examination paper as they would be having their Examination differently from the other students. However she

reassured them that the format would be similar. Before the class, Mick had stated reservations about the Examination paper, as he said that Dr. B had been giving strong hints to his students. After the class, they expressed their worries about Mrs. A not having any input into the paper. They had been working on the past year papers that were set by Dr. B and were worried.

The researcher approached Edward and asked him if he had started his revision. Edward said that he had not started on his revision for Mathematics. The researcher then offered to revise the Mathematics with him. He accepted the offer. The progress of the individual revision sessions will be reported in Section 4.6.

The students were concentrating on the examination questions from the past year papers. The researcher was usually asked about the final examination paper: which topics would come out, did she know the questions, has she seen the paper. Mrs. A had offered to show the paper to her which she refused as she did not want to let slip any information about the paper accidentally. The students were always watching Mrs. A carefully, listening to her every word, looking for hints about the Examination paper. Mrs. A told the researcher that her best defence was that she had forgotten which topics were in it as she had prepared it during the second term.

However, Edward showed the researcher a revision list which he claimed that he had taken off a friend from Dr. B's class which gave revision topics and related it to the examination questions. It was not clear who had given the list. He claimed that Dr. B had given the list but upon further questioning, he could not be sure as he said another friend had a revision list which was different from the one he had. The researcher and Edward had worked solely based on this list. The list was very similar to the eventual examination paper.

The Monday group unfortunately had to miss several tutorials. They had a week out for the first week, and there were two Public Holidays on Monday during the term. Mrs. A organised an extra tutorial for the students on Thursday, 16/5/91. Only 1 person (Dan2) turned up. During the session, it was obvious that he had not

revised. The researcher confirmed this when she talked to him later. He admitted that he had not revised, claiming that he could only revise near the examination as not to forget his Mathematics.

Comments on the observations

It appeared to be a difficult course for Mrs. A to organise as she had to work with several Engineering departments that had planned their students activities without any coordination. The administrative problems that she faced contributed to further muddles along the way. It would appear that the participation of the various groups of students from the different departments were not clearly thought out from the beginning.

Based on the objectives and assumptions that was set at the beginning of the course, the teaching methods that she adopted appeared suitable. The small tutorial groups should have allowed more interactions between lecturer and students thus enabling Mrs. A to identify students' needs and difficulties. However the students' attendance was very variable. They were more regular in the first term, less so in the second term apart from a small group of regular comers.

The behaviour of the Monday tutorial group, though, presented a perspective that was close to the old adage, 'you may lead a horse to water but you cannot make it drink'. Mrs. A efforts was only successful if the students had responded by making known to her what their problems were and what help they required from her.

There were differences in opinions among the students about the effectiveness of her teaching methods and the style of her lectures delivery. There were those who found it suited their way of studying, as they liked working at their own pace and reading from the textbook only what they needed. They were others who thought the course should be taught more didactically as it took too much time to go through the basics on their own. The students who had these opinions were those who had usually taken longer to come to

university after gaining their entrance qualifications. There were some who appeared not to be concerned with the state of affairs one way or the other. They just coped as best as they could. The students were unanimous in their appreciation of the textbook and of Mrs. A's work-scheme sheets. They particularly liked the keywords that she had highlighted in the work-scheme sheets, and the fact that Mrs. A had indicated the amount that they were required to know and to which applications the topics were relevant and necessary.

4.5 The Students

4.5.1 Introduction

This section will present the students' views, responses and observed behaviour as they progressed through the course during the year. It will introduce the students who were in the class and give some insight to their educational and personal background. Their perspectives were obtained through various means. In brief, the researcher had used the following methods:

1. Interviews.
2. Questionnaires.
3. Conversations and discussions.

Among the issues that was raised in the interviews with the students were; their mathematical learning experiences at college or prior to university, why they had decided to come to university, their comments and suggestions on the Mathematics course they were following at LUT and their opinions and reactions to the teaching method that was implemented. During the flow of the interviews, and in conversations, some details of their personal life was touched upon, especially their attitudes toward studying, university education and their hopes for the future.

The notes from the participant observations helped the researcher to balance the students views as volunteered during the interviews and

during any discussions which had taken place on an informal and casual basis during the year. The conversations and discussion was usually written down as soon as possible after the incidents. The interviews were informal too but usually with negotiated pre-determined times and venues. The conversation during these sessions were usually recorded on tape.

Three questionnaires were given out to the students during the research. One questionnaire was from the Department of Mathematical Sciences. It was an evaluation questionnaire designed by Dr. Armstrong, to gather the students feedback on courses provided by the Department of Mathematical Sciences. It was optional for the students to give their names. However, most students who answered the questionnaire gave their names and course designations. Their responses and comments were used to corroborate information gathered by the other sources. Another questionnaire was designed by the researcher. this was mainly aimed at eliciting information about the age of the students, their educational background, and their work experience. The third questionnaire was from the Civil Engineering Department which was only handed out to all their students. Discussion of the questionnaires will follow in Section 4.8.

4.5.2 The Students: Who they are?

The students who were to take up the special provision were originally supposed to come only from the departments of Manufacturing Engineering, Civil Engineering and Mechanical Engineering. However at a later stage, the departments of Electrical and Electronic Engineering decided to send their students. Participation in the class was voluntary though students with BTEC and non-GCE A level qualifications were strongly advised to take up this option. Thus the number of students in the class was variable for the first few weeks of term. The size of the class settled to sixty to sixty five students as three students transferred to their main group at the end of the first term. It was not easy to determine the exact number of students. Mrs. A did not receive any name list from the departments that would indicate the possible number of students

who would be attending. The researcher, however, was given the name list of a group of students on the EMPE course by their Admissions tutor. Mrs. A had asked the students to write down their names in class. She did this exercise twice. However she only checked attendances during tutorials. They were some students who apparently did not turn up for any tutorial during the year. This could not be taken to imply that they had joined the main group as a couple of the students came to take Mrs. A's mid-sessional test. As the students had only to consult their course tutors for a transfer between groups, Mrs. A could not ascertain who were in the class exactly or who had transferred. Only three students were courteous enough to inform Mrs. A of their transfer.

The researcher had hoped to obtain the background information of the students through Mrs. A but she did not have this information. The researcher then decided to hand out a questionnaire which would collect this data. She only received thirty-four replies through the questionnaires. She had also gathered some information through the interviews and discussions, which increased the number of student respondents to forty-seven. Out of these forty-seven respondents, two students left the course, one at the end of the first term and the other dropped out at the end of the second term.

Naza (Malaysian), who left at the end of the first term, had BTEC OND with Level III mathematical qualifications as well as an E grade in Pure and Applied Mathematics (Combined) at GCE A level. He was an overseas student whose sponsors had stipulated that he should do a BTEC course with an additional GCE A level Mathematics. He was with a group of other similarly sponsored students, but they chose to follow the main groups as their grades in the GCE A Mathematics were better than students on the BTEC course. In an interview, Naza admitted that he had not pay much attention to the GCE A level Mathematics while at college as the offers he had received from the universities were based only on the BTEC results. When the interview was conducted early in the first term he had said that he thought it was better for him to be in the slower stream as he did not do well in the GCE A level Mathematics. However, he decided to join the main group after a term with Mrs. A.

Alex who dropped out of the course totally at the end of the second term, had come with American High School qualifications. He was Malaysian but did his pre-university studies in the United States of America. The researcher was told by his friends that he had decided to pursue a different field altogether.

Thus the final total of students who had given information about their background came to forty-five. However data from the eleven students which were not obtained through the questionnaires were not as complete as those who did.

A breakdown of the (1) students age, (2) BTEC qualifications, (3) how they pursued the BTEC/other courses, and (4) the Mathematics qualifications used for entry to university, is given in Table 8.

The researcher felt that the responses obtained reflected the make-up of the class. The majority of the students who had responded had BTEC qualifications which ranged between the BTEC ONC, OND, HNC and HND. They were usually obtained through part-time courses which could be day release, block release, evenings only or through Open and Distance learning. There was a small number of students who had come in with other qualifications. One student had qualifications from a Foundation course, four had Singaporean Polytechnic Diplomas, and one came with a Diploma from India. Another had GCE A levels qualifications but had been working for the last three years prior to entry in an unrelated field. He felt that entry to the provision could give him more time to revise his Mathematics foundations.

The results (Table 8) displayed the wide range of educational background, Mathematics background and age differences of the class that Mrs. A had to teach. Those who answered the questionnaires had also given information about their work experiences which were just as varied. The length of time in employment ranged from a few months of practical training to twenty-five years.

The majority of the students could be considered to be mature students. However the number of years they had taken from gaining

a suitable university entrance qualifications to subsequent entry into the University varies from one individual to the other. The age differences too were large. The oldest was forty-one years old and the youngest recorded from the information obtained was eighteen years old (Table 8).

Surprisingly, 3 students claimed that they only had Level II Mathematics even though they came with HNC qualifications and one student, Rick2, aged forty-one years, claimed that he did not have any Mathematics qualifications though he said that he had several ONC qualifications which he had taken through Open and Distance Learning. He was self-employed and described himself as a Building Consultant since 1980. He had been working far longer than that but in various occupations connected with the Building industries. He was admitted to the Civil Engineering Department.

Of the three who stated that they only had level II Mathematics, Hugh (aged 34 years old), was from the Civil Engineering Department too. He had taken a year of GCE A level mathematics prior upon entry although he did not sit for any examination. He also had about fifteen years working experience in the Building Services. He was accepted for entry a year earlier though he was advised that his mathematical qualifications were a little low. He said that he was further advised by the Admissions Tutor for Civil Engineering, Mr. G, to brush up on his Mathematics before coming to university. He took the advice and had postponed his entry for a year to be able to do the GCE A level Mathematics course. This flexibility in entry requirements for mature and experienced students has been explained by Mr. G (*vide supra* 4.3.3).

The other two candidates who claimed that they had come in with Level II Mathematics were from the Mechanical Engineering Department. Attempts to validate their claims were unsuccessful as the researcher was not able to secure an interview with their Course Tutor. However, in an interview with a former Admissions Tutor of the Mechanical Engineering Department, Mr. H, it was made clear that it could only occur under exceptional circumstances, though highly unlikely. The only possible explanation was that these students had

Table 8

The information below was taken from the questionnaires that was handed out to the students. Thirty-four students replied out of possible sixty to sixty-five. Additional information on a further eleven students were obtained through interviews and casual conversations.

1. Age of the students:

Age(years)	18	19	20	21	22	23	24	25	
Number	1	2	5	9	6	4	1	4	

Age(years)	31	32	34	41	not known			
Number	2	1	1	1	8			

2. Entry Qualifications:

Qualifications	ONC	OND	HNC	HND	not known	Other
Number	3	4	26	2	3	7

Other qualifications: Foundation (1), Singapore Diplomas (4), Indian Diploma (1), GCE A levels (1).

3. How was their studies conducted:

Full time	13
Part-time	29
Not known	3

4. Mathematics qualifications used for entry to university:

BTEC Levels	II	III	IV	V	Non-BTEC
Number	3	14	16	4	8

other subjects with a high Mathematics content. One of the students, Peter1, had distinctions for all the subjects that he had taken on his BTEC course. The researcher did not establish any contact with the other student, information about him was solely taken from the questionnaire.

Having a group with such a varied educational and personal background, it was difficult to portray the typical BTEC student. However, a majority of the students were below 25 years of age (Table 8), single, would have gone through an apprenticeship with some practical experiences of 2-4 years duration. They would have undertaken the BTEC courses while working, usually part-time. The most popular part-time study was on day release. They were usually sponsored by the companies that they were working for. There were, of course, some exceptions.

Matt2 (DME), aged 22 years, married, had been working as a CNC Pouch Press Programmer for a small family company, from 1985-1990. He decided to further his studies as he wanted to further his career in Manufacturing Engineering and Design. He claimed that he had progressed in his work such that the only other post would have been the employer's position which would not have been possible. He had to leave his work, was not sponsored and depended financially on his grant. He had to sell his house in order to buy another nearer to the university. His wife, too, had to leave her job and seek alternative employment.

Most of the BTEC qualified entrants had some work experience as Technicians in their respective fields. Their success in their BTEC studies had given them an incentive to pursue a university education. Some said that they were encouraged by colleagues and lecturers at the Further Education Colleges to "*go for it*". Their working experience had given them some grasp of what they presumed was an engineer's responsibilities and position. Stuart (Civil Engineering) said that he "*preferred to be an Engineer rather than a Technician*". Dave1 (Civil Engineering), said that he had been doing an Engineer's level of work but was not recognised as such without the degree. Steve1 (EME) did one year of an A level course but left

as he felt that he was not able to cope with his studies. He took up an apprenticeship and went on a BTEC course and said, "*it came out at college, my results was quite good*". He, in fact, had distinctions for all subjects. His lecturers at college encouraged him to take up a degree course. He was 21 years old and asserted "*if I don't come now, I never will*".

For the students in the 30-40 years old age bracket, some personal sacrifices were the order as they decided to pursue their university education. Hugh (CIV) had been involved with the design and supervision of Mechanical Building Services Systems from 1976-1989. He found that though he felt that he was capable to do the work, he could not become a chartered engineer without a degree. He was married, not sponsored and had come onto the course using his savings. He explained that he had two reasons for coming to university, to become chartered and that he liked the idea of coming to the university.

Ben (EMPE), also 34 years old, was involved with Maintenance Consultancy work from 1972-1989. He claimed that he had given up a job with a salary of more than £40,000 a year to come to the University. He wanted a change in his life and would like to pursue a teaching career after he graduated, possibly at a polytechnic. He was married but his wife did not move with him as she had a successful career of her own. During the first term, he still undertook some freelance work for his former employers. He said that he had to do it for the money.

For these students, the decision to come to university had meant certain upheaval to their family as well. They claimed that they had considered all these factors carefully and felt that getting a degree was necessary to better their future.

For the overseas students too, the motivation for pursuing degree studies was to better their chances of a good job. There were a total of twelve foreign students in the class. There were four students from Singapore, three from Hong Kong, two from India, two from Malaysia and one from Greece. Six of these students had BTEC

qualifications; three from Hong Kong, one from Malaysia, one from India and one from Greece. However, Raja (EL, from India) also had a Diploma in Mechanical Engineering from a polytechnic in India. He had applied for entry two years previously but was unsuccessful. He claimed that he was told his application was rejected because he had lacked the necessary Mathematics qualification which he in fact had. He claimed that his application form was sent in by his uncle who had not entered his Mathematics results. Raja had shown his Diploma qualifications to the researcher. He was financially supported by his uncle who had also paid for him to take up an BTEC OND course. The Hong Kong students had BTEC qualifications from Hong Kong. The other four overseas students had taken BTEC courses in this country. Out of this total of twelve overseas students, three left Mrs. A's class, two transferred to the main group while Alex left the course.

Three of the students from Singapore, Edward (CIV), Chan and Des (both MEM), claimed that students were given only one chance for higher studies in Singapore. If they had gone to the Polytechnic, they were not allowed to go to the University. They said this was the main reason they left their country to further their studies overseas. They were self-supported. During the interviews, they stated that they were not well off financially but their parents had used various means to support them. Chan's parent had used their insurance money which had matured. Des's and Edward's parents had taken out bank loans. They claimed that success in their studies was a top priority. Edward further said that his younger brother's future depended on his success as he was expected to finance his brother's education after his graduation.

The reputation of British universities were among the other reasons cited for taking up their degree studies here. Nick (MEM, Greek) said that the qualifications from the United Kingdom was respected world-wide and the combination of Manufacturing Engineering and Management could widen his options for employment.

4.5.3 The students' perspectives

During the interviews, the researcher sought out the students' views on various aspects of the course and what they thought their needs and difficulties were as they had come with BTEC Mathematics. For her first interview, the researcher prepared a list of the issues that she would like to discuss. She mentioned that the student was not confined to the list. However, the student, Cy, followed the list literally and linearly. The conversation was very stilted. For the other interviews, the researcher did not show the students the list but used it for her own guide. The interviews were very informally conducted, although the issues were mentioned, and the students were allowed the freedom to say whatever they want. However, the researcher would direct the conversation to pertinent issues if it meandered too much. There were occasions when the interview sessions became lengthy and touched upon personal issues with respect to the students concerned, usually touching on family problems. These sessions were not recorded. During her association with the class and Mrs. A, the researcher had a sneaking feeling that as some students got used to her, she became a sounding board for some of their grievances, an alternative channel when they wanted information about the changes or new developments to the course and to a few, a sympathetic ear to their personal problems. The researcher made every effort to be objective in her appraisal of the situations though she must admit that her interest in the students were genuine and not induced solely by the research. When any student vented their frustration or anger about any aspect of the course, she would take more notice of his conduct in the class and would sought out his views at a later stage. This would enable her to differentiate any heat of the moment outbursts with more entrenched views. Her presence as someone who ostensibly was there for the purpose of researching into their problems apparently was agreeable to most of the students.

The researcher had given out interview request slips during the first lecture. She did receive some replies and sent out another letter to arrange for dates and venues of the interviews. These replies were sent to students' departmental addresses or campus residential

addresses. Many of the students, however, did not reply to the second letter but came up to the researcher during classes to set the times and dates for the interviews; preferring her office for the venue. She also approached students who had said they agreed to be interviewed but had not sent back their replies. She found out that nearly all the letters that she sent out to the departmental addresses were not collected. Even during the third week of term, the few students that she approached said they did not know where their letter boxes were at the department or thought of checking them for messages.

The researcher managed to interview twenty-four students in the first five weeks of term. Out of this number, only eight came back for a second interview during the second term but she conducted a first interview for five more students during the second and third terms. In total, she had interviewed twenty-nine students. She would like to add to this list a thirtieth student, Edward (CIV, Singaporean). She did not interview him, though he answered her questionnaire. However, during the last three weeks before the examination, the researcher helped Edward with his revision. Edward claimed that his last mathematical qualifications was at GCE O level (Singapore). When his claims were checked with Mr. G (Admissions tutor, Civil Engineering Department), the researcher was told that he should have had some Mathematics in his course at Diploma level though it was not specifically called Mathematics. Mr. G was very certain about this information as he had the opportunity to check the syllabus of the polytechnic from which Edward graduated.

A full list of the students interviewed and the dates on which interviews were conducted on is given in Appendix 7. Other discussions and conversations held with these students and others complemented and supplemented the interviews.

4.5.3.1 Educational background and work experience

A majority of the students had HNC qualifications and some work experience. HNC level implied that they had studied BTEC course

units at least to level IV and taken it part-time. The BTEC courses were designed with some flexibility in the choice of units, thus the mathematical qualifications of the students were not necessarily at the same level but could be at level II or level III.

A sample of the students educational background and work experience is given below to illustrate the variety and range of past experience and achievements.

Dan2, MEM, 25 years, (OND)

Dan2 has an OND in Manufacturing Engineering with a distinction in Mathematics at level III. He also had a HNC qualification in Business Studies which he had taken much earlier. He had been managing his parent's farm and had worked for about four years. He said that he wanted a change in career and had decided to pursue a BTEC course in Engineering. He did the course as a full time student.
With respect to the Mathematics syllabus at LUT, he claimed that he had covered most of the topics though he was not sure whether he had done them to the same depth. He said that for him, it was mostly revision and extension.

(Extracts from Interview 1, 30/10/90, week 5, Term 1)

R: *"Do you mind being in a separate class from the A level students?"*

Dan2: *" No, I prefer it er.. as far as I'm concerned er...I recognised that BTEC are disadvantaged to the A level people because they haven't done as much work. As far as I'm concerned they're prepared to split the class to help us gain a little bit more back perhaps to the level of... or attempt to get us back to the level of the A level people then that's fine (inaudible) it works"*

Dan1, MEM, 25 years, (HNC, 1985; level III Mathematics, 1990).

(Extracts from Interview 1, 1/11/90, week 5, term 1)

R: *"What, what BTEC level have you got?" (with reference to the Mathematics)*

Dan1: *"Er..three"*

R: *"Level three and..was it a distinction or a merit.."*

Dan1: *"Um..I got 77% which is a merit..the highest merit"*

R: *"Uhuh so it's the top end..did you do the enhanced BTEC Mathematics at college".*

Dan1: *"er..sorry enhanced* (R: *ya*) *er..no what I did....I..I did a BTEC Higher National Certificate but the actual Maths level in this particular course I did was only worth level two so I work at three different levels of two but they were all two two two and then er.. I did an additional level three whether it was enhanced or not I don't know but.."*

R: *"How many units was it?"*

Dan1: *"Well the two lower units for the ONC was fifteen and ten for the HNC plus an additional one so that I can get enough Maths to come here".*

Dan1 did his HNC two and half years before coming to the University but did his level III Mathematics the year before entry. He had been an apprentice from 1982-1986, worked as a Robot Programmer from 1986-1988 and a Production Engineer from 1988-1990.

<u>Ben, EMPE, 34 years,(HNC, 1989)</u>

Ben tended to speak very fast and rarely paused when he talked.

(Extracts from interview 1, 12/10/90, week 2, term 1)

Ben: *"Ok I give you a bit of background about myself first about Mathematics. The Mathematics I've done previous to this was obviously in school and it was like GCSE and then I left with just that and then I went to Technical College where I carried on doing O level in Mathematics and then I left education for 12 years and never went as I was in the Merchant Navy [R: yes] and then I decided that it was about time I went back so then I went back to do my Ordinary National Certificate where I complete level III Mathematics and I got a distinction in that and I carried on with my Higher National Certificate but there was no Mathematics involved so what I've been doing is the teacher who took us for level III, I was doing some work on my own privately and sending it to her and she was marking it so that was very, it wasn't very consistent because the work and*

I didn't have a lot of free time now when I came... [R: Work meaning that you were working as well] Yes yes the whole time working (R: *Hmm*) *and trying to do some Mathematics. My job involved me travelling all over the world so I didn't have any free time* (R: *Was that in the Merchant Navy as well*) *Yes* (R: *Oh I see*) *I just use to fly from ship to ship and it doesn't matter if you get a phone call you might be you know one day maybe in New Zealand and two days later* (R: *Yes*) *and another call somewhere else. There's very little free time... time time to sort of after yourself..now when I came to the University they told me they were splitting the BTEC scheme which I thought was an excellent idea because I tried to do err..enrol in an A level course but I found out I was so far behind and they taught it slightly differently than the BTEC system where it's more umm.. Pure Maths as opposed to Applied Maths* (R: *Yes*) *that that was quite good* (R: *Which one, the BTEC Maths*) *The BTEC Maths I found it very easy to handle er.. but with the A level Mathematics I found that quite difficult er.. I come to University and they split us up which I think is a good idea umm..if I had a good foundation in Mathematics and I'm not necessarily saying level IV because even the lads with level IV Mathematics are finding it difficult* (R: *Now*) *Yes* (R: *Just after 2 weeks*) *Well I mean let me put it you this way* [he laughs] *now I'm studying now and I have to work every night* (R: *Work as well now*) *Work studying* (R: *Yes working at your work, working at your course, yes*) *At the course, yes, now I have to work every night right* (R: *Yes*) *Mathematics maybe an hour an hour-a-half* (R: *Yes*) *Each night just to try and keep on top* (R: *Hmm*) *it's not only this subject what I'm finding is that without the mathematical skills it's also affecting every other course we're doing* (R: *Hmm*) *because it's just seem to be overlapping* (R: *Hmm*) *and all I've learnt so far is Mathematics* (R: *Yes*) *they haven't taught me anything Electrical as all I've learnt is Mathematics.*

<u>Jill, EL, 19 years, (HNC, 1990)</u>

Jill has Mathematics at BTEC level III and IV with a distinction at level IV.

(Extracts from Interview 1, 17/10/90, week 3, term1)

R: *"How did you find the BTEC Mathematics in the past?"*

Jill: *"Umm well it's been fine for what I needed it for for BTEC courses it's been no problem yeah"*

R: *"How do you find it helping you with the Mathematics in the university?"*

Jill: *"Ya I'm surprised. I was told I..I would have problems but umm there are certain things they do assume I mean I couldn't reel them off now but (inaudible) I think you know are they just assuming that because an A level person would* (R: *Yes*) *but a BTEC person wouldn't but umm overall I'm not finding it too bad at all and I am glad they have um... decided to have a separate BTEC Maths even if it isn't that different it still gives you ah....I was worried about going into the A level people so it kinds of give you security even if it isn't that much different sort of* (R: Yeah) *logically you feel like you're a...doing okay* (R: *Yeah*)

R: *"So you're not having any problems then with your Mathematics on the other parts of the course".*

Jill: *"Umm I don't think so not really, not the Mathematics, other parts of it probably ya".* [laughs together]

Jill had four years working experience in Research and Development, from 1986-1990.

<u>Steve1, EME, 21 years, (HNC, 1990)</u>

Steve1 had HNC at level IV. He had been an apprentice from 1986-1990.

(Extracts from Interview 1, 2/11/90, week 5, term 1)

Steve1: *"I've done er...I did my O level maths at school then I tried doing A levels so I did one year A levels Maths which was Pure and Applied Combined and I find that I was behind. I don't know it's sort of big jump from O level to A level at that time er...I was coping with the Applied side, it was like Physics, I was quite enjoying that, the Pure side was sort of a bit iffy and the lecturer....the teacher that was teaching us at that time, he seemed to...um...all he's done probably what he's meant*

to, was that get the work yourself. He sort of came in (inaudible) and said do this exercise and he sort of run through it and said do this, so Pure Maths...I was coping but I was struggling with it".

R: *"So you finished your Pure and Applied Maths.."*

Steve1: *"No, I dropped what... after I did one year and I've got an OA which is halfway exam and I passed that with a C but that's when I left and start my apprenticeship and so I started with the BTEC lads and I did up to level four which I did and over a year ago now. It's only level five after that but they don't do level five Maths at Highbury, they only went up to level four so...."*

He described the Mathematics that he did at college:

Steve1: *"We did Day Release, one evening and one day a week, it's one evening we did Maths, two hours a week, I think it's 46 that's so many hours we have to do, 46 hours that's sort of lecturing time and then that's sort of homework questions and two (inaudible) test and one in-test but we get on to that umm in level three Maths, for the ONC, we had to do an extra half-unit of Calculus so that when we went next year we can do the whole unit of Maths which they called level four where there was another Maths going on in which half year was done doing Calculus and the other half year was doing sort of first part of level four Maths so I put in an extra half unit in the third sort of er..second year of level three and then we sort of do A level maths for the whole year".*

R: *"And so you did a bit more Mathematics* (Steve1: *I did a bit more Maths..) than the rest of the class.."*

Steve1: *"I.. I did a bit more Maths...there was about twenty of us who did that so.."*

R: *"What is that suppose to do for you* (Steve1: Er...) *is that supposed to so that you can take level four or is that because you can sort of ...*(Steve1: *Yeah, it's basically..) apply to university.."*

Steve1: *"Yeah, they mentioned it at the time so if you're going off to*

university or something er...it's probably better to get more Maths that you can as all that you have it useful and plus sort of the university will accept you more to get into it".

Rick2, CIV, 41 years, (several ONC qualifications, no Mathematics)

(Extracts from Interview 1, 11/3/91, week 10, term 2)

R: *How did you negotiate you entrance into the course?*

Rick2: *"Well I came as a mature student (R: Yes) and mature students get a lot of um... dispensations if you like for past experience (R: Yes) and I mean I've got about, oh, I don't know, the best of 25 years experience in Trade and Building Services.."*

He said that he had worked as a Building Consultant only for the last 11 years. He did various work on site prior to that but he had an accident and had to retrain. He then took up the Structural Engineering side, Building Drawings and Architectural Design though at ONC levels. He claimed that he had ONC qualifications in Building Technology, Civil Engineering Technology and Environmental Science but he had not taken the Mathematics.

R: *How do you manage to follow her Mathematics classes?*

Rick2: *"Um...it's it's very difficult* (laughs) *it's very difficult, she tends to sort of a...oh she go.. she goes off go (inaudible) away, and it... I don't know about the rest of it, you know, the rest of the class but I sort.. I tend to get left behind a bit (laughs) you know and and (inaudible) the time I... I'm sort of (inaudible) scribbling away and making notes and at the end of it I go away with a great stack of notes and it's only half of it probably not even half of it, I don't even know what it means (laughs) you know but I think it's difficult because I'm not a particularly good Mathematician anyway although you know I've done some Structural calculations and Environmental Science and things like that up to ONC level and you know and I've done it sort of to earn a living in that sort of thing (R: Yes) but even so despite all that I don't think of myself as being too good a Mathematician..."*

Rick2 was still maintaining his business while he was studying and described himself as a full-time student and a part-time worker. He would have preferred to study part-time but no such course was available at LUT. He wanted only to attend the universities or institutions near his home as he did not want to move away. He only attended the Mathematics lectures and has never attended any tutorials or surgeries. Mrs. A had offered him help at any time convenient to him even to the extent of giving her home telephone number in case he wanted to contact her during the holidays. The researcher was made to understand that this offer was never taken up.

4.5.3.2 The course and its implementation

In interviews conducted early at the beginning of the Autumn term, many of the interviewees said that they were quite satisfied with the separate arrangements for the Mathematics class. They seemed to appreciate the reasons given for the separate classes. However as the course progressed there were some criticisms as to how the course was taught, worries about the examination arrangements and concerns as to whether they in fact had extra time for their Mathematics.

Nick (MEM, HND)

(Extracts from Interview 1, 24/10/90, week 4, term 1)

R: *"Do you know the way Mrs A has conducted the course, do you like the way she has planned* (Nick: *Yeah*) *the work scheme"*

Nick: *"Yeah, quite useful especially with this book. I like this book. Umm er..it's called er I can't remember exactly* (R: *Stroud*) *Yeah, yeah it's really useful. I like this course, it's quite practical, this way, it gives you a progressive let's say er.. knowledge, it just start with the easier exercise and it go on to harder...I had this book last year as well"*

R: *"But you have to work on your own, how do you feel about that"*

Nick: *"Well er...maybe for me this is not a problem because I'm*

enjoying. I like maths but er... for someone else maybe it's different I don't know but that's the university. That's why the university is different from the technologies if you er....well you don't have to have someone push you do something. You want to study because you like the area probably you've chosen that's your life anyway. You spend how many hours per day on this subject probably in your life so you have to enjoy it."

A few students found the teaching suited their needs and praised Mrs. A for her teaching.

(Dan2, MEM, Extracts from Interview 1, 1/11/90, week 5, term 1)

"I always had to work hard at Maths to get any success I mean it's not er.. my my best subject so to speak, but I.. I always managed with with working hard. There's always the.. the.. er.. the teaching format has been quite adequate. I'm quite happy with it. Yeah I mean Mrs A's methods and the way she every week, you have a sheet in front of you, you know exactly what you've got to do, it's all prepared, lot of the work is done for you. I mean, like as much as to say.. like to say 'that's what I think you should do and if you do that, you'll pass the course' and so you think 'oh I know what I've got to do' rather than sort of like some lecturers just come in, go up to the board and sort of start waving their arms around...(inaudible)..*they don't explain things to you very well. I think she explains things quite well. I'm quite pleased with how things are going."*

Paul, 34 years, EMPE, HNC, level IV Mathematics.

(Extracts from Interview 1, 1/11/90, week 5, term 1)

R: *"Do you like being in Mrs A's class, I mean do you mind that the class being split up?"*

Paul: *"No, I think it's good and I I think Mrs A is a good teacher"*

Some criticisms of Mrs. A's teaching revolved around the pace of the course and her style of delivery. A few students found the pace too fast though they admitted that it was the same in all the other

subjects. Some comments on her delivery techniques were made by students and has been presented in 4.5.2. In one particular incident, Matt2 voiced his frustrations to the researcher, claiming that there were too many gaps in his notes, referring to Mrs. A who left out some steps in the working of examples. He further said that he had to go along to surgery just to ask Mrs. A to explain the notes. In the second term, however, Matt2 said that he felt the course was getting better and he could follow the lectures. He admitted that he found the first term difficult but was relieved that he had managed to cope with the work after all though he said he still had to work hard at Mathematics. He had attended the lectures and tutorials regularly, was always vocal about his problems and usually made them known to Mrs. A.

In a group interview (1/11/90) which was conducted for Stuart, Dave1 and Hugh (CIV), they voiced their concerns about the fast pace and the presentation of the course. Stuart and Dave (21 years) came with level IV Mathematics but Hugh (34 years) had only level II.

(Extracts from Interview 1, 1/11/90, week 5, term 1)

Hugh: *"Certainly on this course, we don't, the lectures isn't given to you is it* (Stuart and Dave1 laughs) *the amount of work I'm finding that I have to do at weekends is so much that the other subjects has been suffering through spending whole days on the weekend just on Mathematics. I don't think it should be like that.."* (laughs).

Stuart picked up the conversation and said,

Stuart: *"I don't think really the lecturer's bad, I.. I think that there's so much to lecture that really is not given to us , it's just shown to us and really I've got to be fair, tutorials are quite useful but the lectures I could probably do without them. I sit in the lecture and listen and may pick up 10 % and I go home and I go through the Stroud book and remember that one. I don't find really much in the lectures but I think that's more because I'm not... it's me not the lecturer."*

Hugh: *"I think you have....we're having to teach ourselves the subject*

(Dave1 & Stuart: *Yeah) and it takes a lot more more time than if somebody teaches you it as a subject."*

Stuart: *"That's the* (inaudible) *because when you're learning it yourself you got to sit down and it takes hours to pick up the basics and the rest comes easily but if you move the basics better and just taught those then you'd probably be able to pick up the subjects and the work at home would probably be less."*

R: *"How are you finding it?* "(directing the question to Dave1)

Dave1: *"I agree with these two. You're virtually told the subjects and then go and find out by yourselves which takes up a lot more time and make it harder."*

Mrs. A sometimes made minor arithmetical mistakes while she worked out her examples, which the Singapore students found exasperating. They felt that it made her look bad as if "she's too old for the job". This was referring directly to Mrs. A's jokes about being forgetful or that she was getting old. Nevertheless, the mistakes were usually very small. They liked the way she usually followed the book closely, as that made it easier for them to catch up, but they (the Singapore students) found her notes difficult to understand because there were too many gaps in her workings. They found that it took too much time just to work out the problems all over again.

The researcher is Malaysian and she realised that the Singapore students were voicing views that reflected the teaching culture in their respective countries which was similar, in that lecturers were required to appear to the students as masters of their subjects and should avoid mistakes in class. Mrs. A, however, did make small mistakes, she joked about them, accepted corrections from students readily and usually appeared as if she was thinking aloud when she did the examples. It did not appear to worry the local students much but it was making some of the overseas students lose confidence in her ability.

4.5.3.3 Administration and organisation of the course

It has been reported elsewhere (*vide supra* 4.5) on the various changes that Mrs. A had to make during the year with respect to her teaching plan in response to the demands made upon the students by their various parent departments. Inevitably, a week off for one or two groups of students meant that Mrs. A had to adjust for their absence and thus this had an impact on the students from the other departments as well. The return of the students from the Electrical and Electronics Department to the main group had affected the allocation of topics and teaching time greatly (*vide supra* 4.5.2).

In the first lecture of the year, Mrs. A had introduced her course, teaching methods, resource materials, and checked on the allocation of contact hours. In the second lecture, she had gone straight into the first topic of the syllabus (*vide supra* 4.5.2.1). However, students from the Civil Engineering Department had missed the first week due to other programmes that were held by their department. Mrs. A had repeated any explanations about her teaching styles though her subsequent explanations were more brief.

There were other differences affecting the students from the Civil Engineering Department. Dr. B, who taught Mathematics to the main group had assigned Computing courseworks to his students which the BTEC group had to do as well.

(Extracts from Interview 1, 1/11/90, week 5, term 1):

Stuart: *We have a BASIC er.. er sort of coursework to do and so we're attacking Computer BASIC courseworks without the...er...sort of er... lectures that was given to the other students"*

R: *"Do you have to do the coursework as well?"*

Stuart: *"Yes, we have Computer lessons that should be two hours every fortnight but because we do this tutorial, we're down here, we only get one hour every fortnight* (R: *Do you..*) *because because there's no other time to put it in."*

Hugh: *"Am I just ....am I getting a bit confused here.....do..do the A A level maths do some Computer BASIC in their Maths .."*

R: *"It seems so, I just saw what Stuart puts down, what Dr. B is doing and it seems so he's doing some, a bit of BASIC and a bit of FORTRAN in the lectures."*

Hugh: *"I didn't realise that.."*

The students claimed that time-tabling difficulties had blocked their Computing classes with the Mathematics tutorial. Mrs. A was surprised when she was told this by the students as she was given the time slot by the Civil Engineering Department. Mrs. A wanted to make other arrangements but the students told her it was not a problem for them to attend the tutorial.

Later in the discussion, Hugh was surprised to find out that he had Computer coursework to hand in as well. The researcher was surprised as well as she thought that all the students were assessed 100% at the end of year examination.

(Extracts from Interview 1, 1/11/90, week 5, term 1):

Stuart: *"He said that we had two Computer courseworks, one on the Spreadsheet* (Dave1: *FORTRAN) and one on BASIC.."*

Hugh: *"You mean he mix the Computer lessons with the Maths lessons.."*

Stuart felt that the A level students had an advantage over them on the Computing lectures as the lectures were delivered by Dr. B in the Mathematics class. They were given alternative arrangements for the Computing but,

Stuart: *"But we.. we had Maths and Computing..because of this lesson we only do an hour a fortnight instead of two hours a fortnight* (R: *Hmm). I think it's a bit muddled, they haven't ..I don't think they have really thought about this year about the Civils.. because because we miss the first week* (R: *yes you did..). which we had the Induction course which was something we probably done before, everything* (inaudible) (R: *what did you do in the first week? I was wondering about that,* [they laughed] *it's not called Induction as well, it's called Inception as opposed to Reception I suppose)"*

Hugh: *"Well nothing* (inaudible) *we've done it and they er..one or two tutors was casting around giving out feedback on it and I think we* (inaudible) *them it's too long two days* (Dave1: *Uhuh*) *showing where everything is, what facilities there are, now can be done in two days not five* (R: *I* see (rest of comments inaudible))"

Stuart: *"I think some of our subjects took time to get started...."*

Stuart, Hugh and Dave1 said they would have preferred to attend only certain key Mathematics lectures in the first week if their department would have allowed this.

During a conversation with Stuart and Dave1, Stuart repeated his worries about the Computing coursework.

(Extracts from field notes, 5/2/91, week 5, term 2):

Stuart: *"Well, mind you, I've been worried about the course, well, Dr. B has been doing bits of FORTRAN and BASIC in his class, and I've got to do a coursework that needs BASIC."*

R: *"Didn't you do it in the Computer Class?"*

Stuart and Dave1: *"No."*

They said that they were not blaming Mrs. A for these differences. They felt that some members of staff of the Civil Engineering Department did not know about the BTEC class. They claimed that they had also missed other announcements and handouts. Once they did not receive forms from the Institute of Civil Engineers as they were usually handed out to the main group. Another incident was quoted when they were not told that the date due for a particular assignment was moved forward and they handed in their assignments late. The Civil Engineering students were on different courses but were grouped together for Mathematics and thus other members of staff preferred to give announcements or handouts during the main Mathematics sessions. Stuart said, *"feels like we've been forgotten"*.

Some students complaints were not directed to the Mathematics course in particular but generally toward the whole course they were on.

Among these were the sequences of the Mathematics topics (as taught by Mrs. A) and as required in their other Engineering subjects. They felt that if the sequences of topics were better co-ordinated, they would be able to follow the Mathematics required in their Engineering subjects better. The coursework given out by different lecturers too might be better coordinated as sometimes they had too much to do and at other times too little. The students from the Manufacturing Engineering Department, were not happy with the weeks out for Engineering Application. They claimed that often when they had assignments to hand in, their other work had to be shunted down the line of priority. For Mathematics in particular, some claimed they were a bit behind though they were others who managed to keep up. They recognised that Mrs. A had organised her lectures for the weeks out, once she knew when they were, so that key lectures were repeated.

Mrs. A told the students of the changes in the examination arrangements in the first week of the Summer term. The students were very worried about this particular development though Mrs. A tried to allay their worries. She conducted a series of revision classes throughout the Summer term, working through most of the questions from the different Departments' examination papers. It has been reported earlier (*vide supra* 4.5.2.1) that the students were very concerned about the examinations from the start of the course.

In conversations with students from the Civil Engineering and Electrical and Electronic Engineering Departments, they were quite unanimous in their opinions that if they knew the examinations were to be separate, they would have rather be with the main group and taught by the lecturer who was to set the examination questions. Paul and Ben (EMPE) in particular said that the separate class was a very good idea but found themselves floundering in Mr. D's class as the topics seemed more difficult and the past examination questions were difficult too and they had to get to use to his teaching style. Ben said that one of their friends (Guy) went to Mrs. A for help with the questions from the past year papers and he would pass the solutions to the other BTEC students. When the researcher met them, they had already sat for the examination and they were not too hopeful of

passing the Mathematics but hoped that marks from the other subjects would pull them through.

4.6 Revision sessions with Edward

Edward (CIV) had told the researcher that his Mathematics qualifications was only at GCE O level (Singapore) which was disputed by Mr. G (*vide supra* 4.3.3). During the year, it was obvious to the researcher that Edward had difficulties in following the Mathematics. She found this out from conversations with him and with observing his work during the tutorials. He attended the lectures and tutorial sessions regularly but was usually quiet in class. The researcher had frequently advised Edward to seek Mrs. A's help but he was most reluctant to show her the extent of his weakness in Mathematics.

In the tutorial sessions in the Summer term, Mrs. A usually went through past examination questions with the students. In one of these sessions, the researcher found Edward quite depressed as he was unable to follow the solutions that Mrs. A had presented. The researcher offered to revise the Mathematics with him and he accepted. She also invited Hugh to come to these sessions but he declined as he could not come at the times that was set between her and Edward. There was three weeks to go until the examinations.

During the first revision session (13/5/91), the researcher asked Edward his revision plan. He told her that he wanted to choose certain topics and concentrate only on questions based on these topics in the examination. He had started some work on Functions but said that he was omitting Differentiation as he found that he did not understand it at all. She showed Edward questions from the past year papers to illustrate how differentiation was required for nearly all the questions, either asked directly or required in working out certain parts of the questions. The researcher suggested that they should look at differentiation as it was an important topic and should not be left out. He agreed but thought that he would work on it during the summer vacation. She persuaded Edward to look at

Differentiation first and told him that he could omit it later after they had gone through the topic, if he still wanted to.

The researcher gave Edward her copy of Mrs. A's foundation notes on Differentiation. Edward asked her, "What is Differentiation?". He claimed that he did not understand the topic at all. Using the notes and the textbook, the researcher started from the definition of Differentiation and worked through the topic. The researcher showed him a few examples using the basic formula and asked him to try a few on his own. He seemed to manage the easy examples quite well. She asked him to read through the relevant sections in Stroud and to try more of the exercises. She asked him to bring along his Mathematical tables so that he knew how much information was in the book, to reduce the need for memorisation. The tables was made available to students in the examinations.

The sessions were usually of about two to three hours duration at times mutually agreed. The researcher at first worked through the topics with Edward, using Mrs. A's work scheme sheets, checking the keyword list. Edward appeared to be able to do the exercises quite well. If he found some of the problems difficult, the researcher went through the examples with him, pointed out his mistakes and gave him other similar examples to work on. However, in one of the sessions, Edward produced a list of revision topics which he claimed he had taken off a friend from Dr. B's class. The researcher decided to revise the topics based on the revision list, and they tried solving similar questions from the past year papers.

The researcher was aware that the sessions was planned in order to ensure that Edward could pass the examinations. It was selective revision and she told him that he would need more help to be able to really appreciate and understand the topics so that he could cope better in the second year.

Edward was a quick learner and they had three more sessions, one in week 5 and two in week 6. They managed to go through other topics such as Integration, Partial Fractions, Partial Differentiation and first order Ordinary Differential Equations. He already had 17% from his

coursework and was targeting to get about 30% from his examination. He was only aiming to pass Mathematics. He claimed that he did not fare too badly in the other subjects.

The researcher was surprised when the final paper was shown to her as it followed the revision guide quite closely. Edward did pass the Mathematics and the whole course as well.

4.7 Examinations and Students' Results

As reported (*vide supra* 4.5) the examinations was supposed to be a common paper for all the Engineering students. The Engineering Departments, however, had planned their examinations sessions at different times. Eventually, the Civil Engineering students sat for their Mathematics examination earlier than the others. Their paper was set by Dr. B which was presented in the same style and format as for the other students.

The paper jointly prepared by Dr. B, Dr. C and Mrs. A was taken by students from the Mechanical Engineering and Manufacturing Engineering students. The Electrical and Electronics Engineering students sat for a separate paper set by Mr.G.

The assessment for Mathematics was based on 100% from the examination papers for all the Engineering students except those from the Civil Engineering Department. Dr. B had assigned for these students in his group, 20% for coursework and 80% from the examination. Civil Engineering students in Mrs. A's class were required to do the coursework too.

The students preoccupation with the examination was very clear from the beginning of the academic year (*vide supra* 4.5.2.1). They were most anxious about the format and style of questions to be set as well as who was setting them. They felt that it was important to get accustomed to the particular lecturer's style of teaching and how he/she set the questions.

Students progress from first to the second year in the Engineering Departments was based solely on their overall performance in examinations. Students were allowed to fail one subject but if they failed more than one, they had to retake the whole year. It would have been possible for students to progress even if they failed in their Mathematics but were able to secure good marks in the other subjects as to maintain a pass overall. The pass mark was stated to be 45%.

The researcher was not able to obtain the examination results of the students under observation, but Mr. G and Dr. F (Admissions tutors of the Civil Engineering and the Manufacturing Engineering Departments respectively) were obliging enough to inform her of the students performance verbally. However, Mrs. A allowed the researcher to look at the results of students whose papers she had marked. They were from the Manufacturing Engineering and Mechanical Engineering Departments.

All the students from the BTEC group in the Civil Engineering Department passed the year except for Rick2. Rick2 was still working while he was on the course and he only attended the Mathematics lectures. He did not attend any tutorial session. It seemed that his attendance at other classes was similarly limited.

The overall Mathematics results was described as "rather disappointing" by one senior lecturer, Dr. N (interviewed on 14/2/92), of the Manufacturing Engineering Department. He had been appointed as a 'liaison officer' between his Department and the Mathematical Sciences Department and was asked to take a particular interest in the BTEC entrants, although he added that this was some time ago. It was the duty of the Course Tutors to look after the first year students including the BTEC entrants.

However, in an interview with one of the Course tutors, Dr. L, for the Electronics and Manufacturing Engineering course (EME), that tutor expressed his satisfaction with the performance of his students.

(Extracts from Interview with Dr. L, 5/3/92)

"As far as Mathematics was concerned, we had a higher average mark last year overall than we would normally expect. The overall mark was around 53%."

He informed the researcher that two students failed the course and one of them was from the BTEC group. The student concerned was not only weak in Mathematics but was weak in the other subjects as well. The other was from the A level group who had marginally failed but was allowed to proceed to the second year. Two BTEC students passed the year but did not pass the Mathematics.

Dr. M (interviewed on 16/3/92), Course tutor for the Design and Manufacturing Engineering Course said that no individual student had come to him to talk of their problems, especially with Mathematics, and the only feedback he had was the examination results. Unfortunately he did not have the results for the BTEC entrants at hand during the interview.

Mrs. A was quite concerned about the performance of the 'BTEC students' in the Electrical and Electronics Engineering Department. There was no information available to the researcher about their Mathematics results but Mrs. A found out that the students in the Electrical and Electronics Department had progressed to the second year.

4.8 Questionnaires

Three questionnaires were given out to the students during the year. These were:

1. from the Civil Engineering Department for their students only;
2. from the researcher;
3. from the Mathematical Sciences Department.

4.8.1 Civil Engineering Department questionnaire

The Civil Engineering Department questionnaires were handed out to the students on 9/11/90 (week 6, term 1). Mrs. A handed the questionnaires out to the Civil students before the start of the class. She then proceeded with her lecture. At the end of the class, the students concerned were asked to hand in their questionnaires. One of the students (Rick2) handed his promptly and left. The others were still answering their questionnaires and Mrs. A had to wait for them. She collected six questionnaires. The questionnaire was for the students to evaluate the Mathematics course and how it was taught. During the tutorial session which followed the class, another of the Civil student came and was asked to fill in his questionnaire. Thus, Mrs. A collected seven questionnaires from the students.

She allowed the researcher to look at the questionnaires in the afternoon and gave her a summary of the students' responses (Appendix 4(1)).

4.8.2 The researcher's questionnaire

The questionnaire was handed out to the students on a Tuesday morning lecture session (19/2/91, week 7, term 2). The researcher was allowed a few minutes to address the students to explain the questionnaire. The students were asked to return the questionnaires within a week, if possible the Tuesday next.

The questionnaire was mainly a data seeking exercise, to find out about the students Mathematics background, what were their entrance qualifications and work experience (Appendix 4(2)). The researcher felt that it was necessary to hand out the questionnaires as the students who responded to the interview request were about a third of the class only. Mrs. A did not have information about the students' background. This was unfortunate since information gathered by the researcher during interviews with FE staff and the students themselves had shown that the students' background was varied. Their BTEC qualifications and the levels they had achieved in their

Mathematics did not indicate clearly the amount of Mathematics they had done unless they included the units they had taken. In the questionnaire, the researcher requested information on the Unit title and code so that she could compare this with the BTEC syllabus. Unfortunately, the students did not know or remember this information. They did manage to give the units of Mathematics they had taken and the results they had achieved. A summary of some of the information collected was given in Table 8.

The researcher had hoped to increase the number of respondents via the questionnaires but only thirty-four questionnaires was returned. Some of the students who answered the questionnaire had not been interviewed but most were students with whom she had established some contact. They were students who were interviewed but did not fill in the questionnaires. In total, she managed to collect information for forty-five students. It should be noted that the attendance in the class was quite low when the questionnaires were handed out.

4.8.3 The Mathematical Sciences Department Questionnaire

The questionnaire (Appendix 4(3)) was in fact a pilot issue and was prepared by Dr. Armstrong for the Department. It was designed to gather students feedback for course evaluation. Mrs. A had requested that the questionnaires were handed out to her students. The questionnaire was handed out at the end of the second term (Tuesday, 12/3/91, week 10) as Mrs. A wanted students from the Electrical and Electronics Engineering Department to participate.

Mrs. A had finished her lectures early and had passed out the questionnaires for the students to fill in during the class. She had allocated twenty minutes for the students to fill in the questionnaires. The attendance was low and she collected only forty-two returns.

A couple of students had raised a few queries on some of the wordings in the questionnaire and some were discussing it. The Hong Kong boys were in constant discussion with the Singaporean boys

about the questionnaire. The researcher suspected that they did not understand some of the questions. They were talking in Chinese.

However, the students responses and comments were most helpful to Mrs. A and the researcher. The researcher had helped to prepare the summaries of the results from the questionnaires for the whole class and for the individual departmental groupings. These are given in Appendix 8.

Written comments from students whom the researcher knew, were consistent with their comments and views given during interviews and conversations. The students unanimously agreed that Stroud was a most suitable textbook. Their comments on the teaching and the pace of the course were less homogeneous. A few students commented later to the researcher that it was difficult to answer the question as they did not have anything else to compare it with and there were other students who said that it would be impossible to present a course at a pace that everyone found suitable as they had different mathematical abilities to start with.

Generally, the students liked the idea of gathering students feedback, they liked to give their ideas on the course and its contents.

4.9 Comments

During the study, the researcher had noted some of the more obvious students' difficulties in Mathematics. She agreed that there was considerable lack of background knowledge among the students but there was some differences as to which topics they were lacking in. She had recorded some students claiming that they had not done any Vectors though they had level IV BTEC Mathematics and there were others who claimed that they had not done any Inequalities. In one of the first few sessions, some students claimed they had not done any Complex Numbers when asked by Mrs. A. It was difficult to gauge whether the students really did not do the topics or that tney had forgotten the topics or in the case of a few students, they could not place the concepts within the terminologies. For example, Matt2 found

mathematical terms difficult to reconcile with its contents. He claimed that he could not remember what Partial Differentiation meant but could do the problems and examples.

During the tutorials, both Mrs. A and the researcher found that the students were slowed down by the arithmetical manipulations rather than the topic under study. Factorisation was a problem. There was also a constant need to be able to visualise the problem. When Mrs. A showed how to translate graphs using her hands, the students found the topic quite easy. There was also frequent requests for Mrs. A to illustrate the relevancy of the Mathematics to Engineering situations and for more practical examples. However, for Rick1 (EL) and Rick2 (CIV), practical examples meant working with real numbers.

Some of the students agreed that though they had covered virtually all the topics in the BTEC course, it was to sufficient depth to enable them to cope with the first year Mathematics. Dan2 described the first year work as "revision and expansion".

Some found the change in teaching styles difficult to adjust to and felt quite lost without supervision in their studies. They said that they had frequent set assignments as part of the BTEC studies and liked the structure as it made them work. Mrs. A frequently gave advice during tutorials on how to organise their study, sometimes with practical examples on exactly what to do. However it appeared that some students were unable to develop a suitable study strategy to cope with the different teaching style at university. Other students claimed that they were quite used to working on their own but would also preferred some marked assignments so that they could be sure that they had picked up the necessary mathematical skills.

In one particular case, Rick2 (41 years old) felt quite conscious of the age difference and found working with the younger students difficult. He usually sat alone in class, rarely talked to the other students, except to Mrs. A and the researcher. Ben (34 years old) and Paul (32 years old), both on the EMPE course, got on quite well with the other students but sometimes felt that the younger students

were not serious enough in their attitudes towards studying and preferred not to join in the social life at university.

4.10 Glossary: Tutorial Groups and Time-tabled Sessions

1. Abbreviations for the Course Groups.

CIVIL ENGINEERING

1. Civil Engineering	CIV
2. Building Services Engineering	CIV

ELECRTRONIC & ELECTRICAL ENGINEERING

1. Electronic and Electrical Engineering	EL
2. Electronic, Computer and Systems Engineering	ECS
3. Electro-Mechanical Power Engineering	EMPE

MANUFACTURING ENGINEERING

1. Manufacturing Engineering and Management	MEM
2. Design and Manufacturing Engineering	DME
3. Electronics and Manufacturing Engineering	EME

MECHANICAL ENGINEERING MECH

2. Tutorial Groupings

AUTUMN TERM	SPRING TERM	SUMMER TERM
MEM	MEM	MEM
MECH/EMPE	MECH	MECH
DME/EME	DME/EME	DME/EME
EL/ECS	EL/ECS	CIV
CIV	CIV	
	EMPE	

Note: During the Spring term, the tutorial for the EMPE was actually blocked with tutorials of other subjects and the students had to choose which of these to attend or make appointments for.

3. Surgery

AUTUMN/SPRING TERM:
Monday, 3.10-4.00pm
Wednesday, 11.10-12.00noon and 2.00-2.55pm.

SUMMER TERM
By appointment.

CHAPTER 5

CONCLUSIONS, THEORY AND RECOMMENDATIONS

5.0 Introduction

This research has been based on a perspective and on methodologies which are suitable for a programme which necessarily gathers qualitative data. From a comprehensive initial literature review, it became apparent that there had been few researches, if any, conducted on the Mathematics education of students in higher education using qualitative methods. From the outset, it was intended that the thesis would offer a description and a portrayal of a particular Mathematics course innovation and that the research would lead to a better understanding of the complexity of the interchanges between students and teachers during the course.

For the purpose of analysis in this Masters thesis, data was selected judiciously from the massive volume of the total data collected. The data which was not selected, however, would form a basis of further research, at a higher level. For instance, much of the data concerns the behaviour, beliefs and changes of individual participants whereas the data selected for analysis in this research mainly refers to curriculum matters. However, a significant amount of personal data is included in the case study of this research (*vide supra* 4.6) in order to assist interpretations of the work and its findings and to enhance validity.

5.1 Curriculum development in Mathematics in Higher Education

The term 'higher education' in the United Kingdom usually refers to post GCE A level courses provided mainly by universities, polytechnics, and colleges or institutes of higher education. Entry requirements to higher education courses are commonly stated in terms of the GCE A level qualifications. The exact number of GCE A levels required depend on the courses offered at the various institutions. Other entry qualifications (for example: Scottish Higher

Nationals, BTEC ONC/OND and HNC/HND, certain overseas qualifications) are also accepted but the standard appears to be the GCE A level qualifications (Squires, 1987). Some degree of flexibility is exercised in the intake procedures, especially toward the recruitment of mature and overseas students. Recently there have been efforts to widen access to these courses whereby the higher education establishments will accept students with non-traditional qualifications such as those coming in through ACCESS courses.

Much of the research on the Mathematics curriculum has tended to focus on Mathematics in school education, primary and secondary (Howson, Keitel & Kilpatrick, 1981; Howson, 1983). Discussion and research on curriculum developments in higher education has tended to be within specific disciplines due to the specialised nature of the different disciplines (Squires, 1990). A review of Mathematics courses implemented at various institutions within the United Kingdom and other parts of the world (*vide supra* 2.1), has highlighted the concern about the teaching of Mathematics to students who are considered relatively weak in Mathematics upon entry to higher education. In the United Kingdom, such students are consistently identified as having had ONC/OND or later, BTEC ONC/OND entry qualifications. The literature review conducted by this researcher also highlighted the fact that curriculum developments and innovation in Mathematics in higher education has tended to be effected significantly, in individual institutions; by the beliefs, preferences and personal experiences of an individual or of members of the teaching staff working in a team. The high mathematical qualifications of teachers in higher education establishments, some degree of autonomy given to the individual establishments and the nature of higher education seems to be responsible for this state of affairs. The implementation of any innovation in the Mathematics teaching at university level has tended to depend on the Mathematics teachers own interests or research. The theoretical stances of curriculum research are not always clear but the research methodologies used have always favoured the scientific and rational approaches. Discussions or exchanges of experiences of particular curriculum innovations between teachers within or of different institutions are

conducted, usually through conferences, seminars, and journals (*vide supra* 2.1).

5.2 Models of curriculum development

Taylor and Richards (1986) have categorised curriculum theory broadly into two types: systematic, sometimes called rational or scientific, and naturalistic. Though this categorisation is considered an over simplification, it serves as a good setting to develop the analysis of this research. The research was focused on a specific subject, Mathematics, within the first year undergraduates Engineering education curriculum. The term 'curriculum' is more commonly used with reference to school learning experiences but not widely used with reference to higher education (Squires, 1990; Miller, 1987). Undergraduate studies are usually referred to in terms of courses, programmes, syllabuses or modules. Miller (1987) suggested that in higher education, a good definition of curriculum would be '*the total planned learning programme for any one student*'. Such a definition would allow for cases where students were given some choice in subjects within their undergraduate studies. In this particular research, though Mathematics was considered an important subject in the Engineering education curriculum, it was taught by lecturers from the Mathematical Sciences Department who provided service for the various Engineering Departments. The planning, design and teaching of the subject was left entirely to the responsible Mathematics lecturer. Thus it was considered appropriate to consider the planning, design and implementation of the Mathematics course as a curriculum innovation in its own right.

Writing about higher education tends to advocate the rational approaches to curriculum planning and design (Beard & Hartley, 1984; Miller, 1987). The rational approach would suppose a goal-directed, systematic planning and one that is based on theory. The aims would be to provide prescription and guidance in curricula practices. With naturalistic curriculum theory, the aims are 'to provide description, explanation, understanding, and, if possible, prediction' of the curricula practices (Taylor and Richards, 1986). Actual accounts of

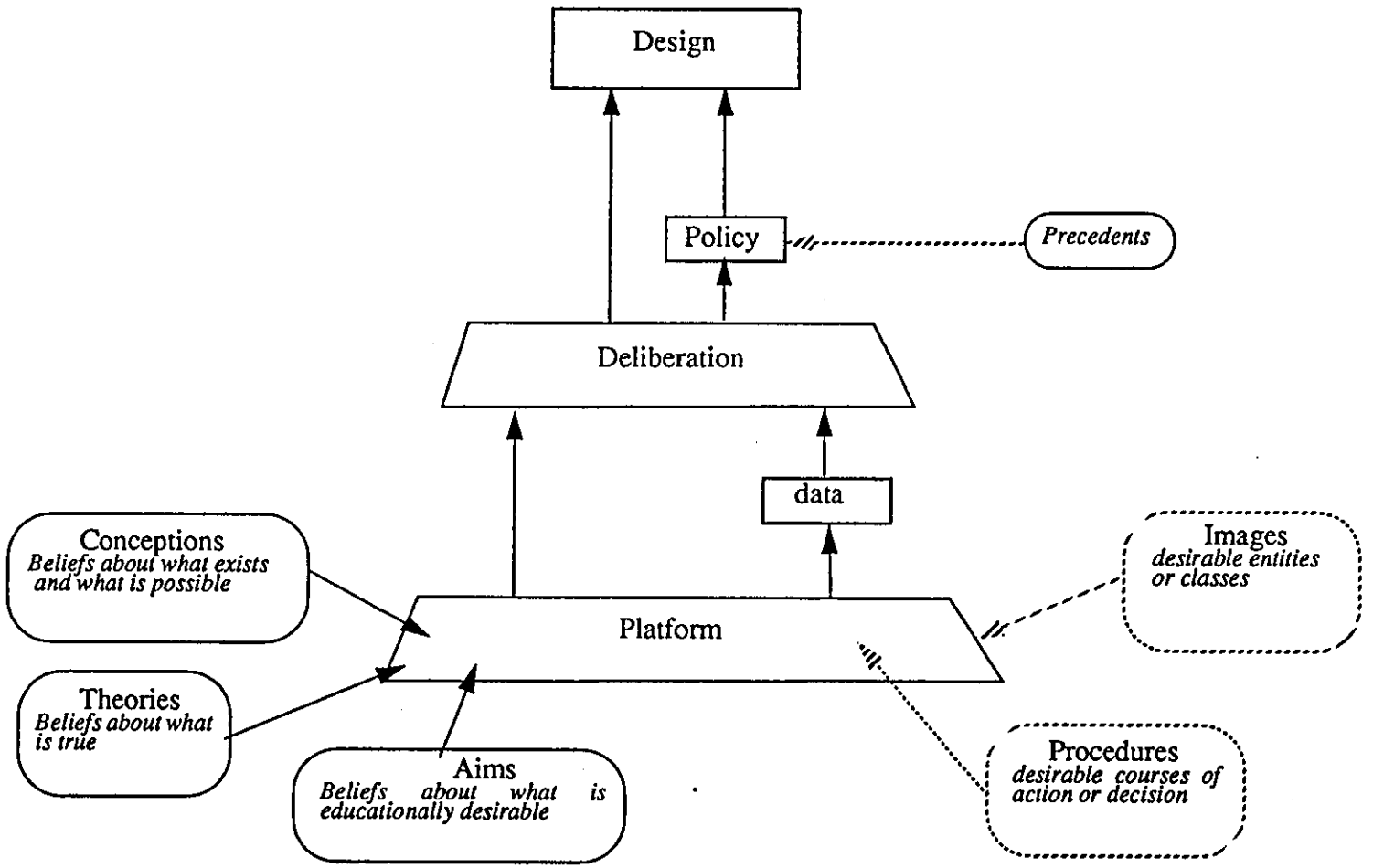
courses being implemented (Parlett & King, 1971; Billing, 1978) in higher education suggest that the approaches used tend to depend on more pragmatic considerations and to rely heavily on comparisons with other curriculum developments, implemented in the past within the same institution, or to other courses at other establishments rather than to theory. This state of affairs appears to be more in line with naturalistic curriculum theorizing than with scientific, rational approach.

As this research progressed, the process of 'progressive focusing' (Glaser and Strauss, 1968) identified curriculum design and development as the most fruitful area which a theory would emerge. In the event that theory took the form of a naturalistic model which, it is suggested, adds to the body of theory in this field (Walker, 1971; Armstrong, 1990). It is important to distinguish this field of naturalistic models from the field of prescriptive curriculum models (Appendix 9). A brief description of the naturalistic models is now given since the purpose of the theory and model developed by this researcher is to build and modify the work already done on naturalistic models.

5.2.1 Naturalistic models of curriculum development

There have been few detailed accounts of how curriculum planners actually design and produce their proposals. Walker (1971, 1975) produced a descriptive naturalistic model (Figure 2) of curriculum development based on reports of various North American projects and in particular with his observation and participation with the Kettering Project (Walker, 1975). The latter project was aimed at designing and producing curricula and instructional materials for art education in elementary schools in the USA. He found that the planners own beliefs and assumptions, which subsequently guided their thinking and planning, had a considerable effect on the curriculum design and thus should be considered as part of the planning process. He described these beliefs and assumptions as the platform of his curriculum model.

Figure 2: A 'Naturalistic' Model: Decker F. Walker, 1971



A later model (Figure 3), though developed for the design and development of INSET schemes (Armstrong, 1990), included beliefs in a different manner. This model was described in two parts: (1) The four phase developmental model and (2) The evaluation structure model. In the first part of his model, Armstrong identified four phases:

(1) Exploration and problem identification
(2) Problem selection and familiarisation
(3) Outline planning
(4) Progressive development

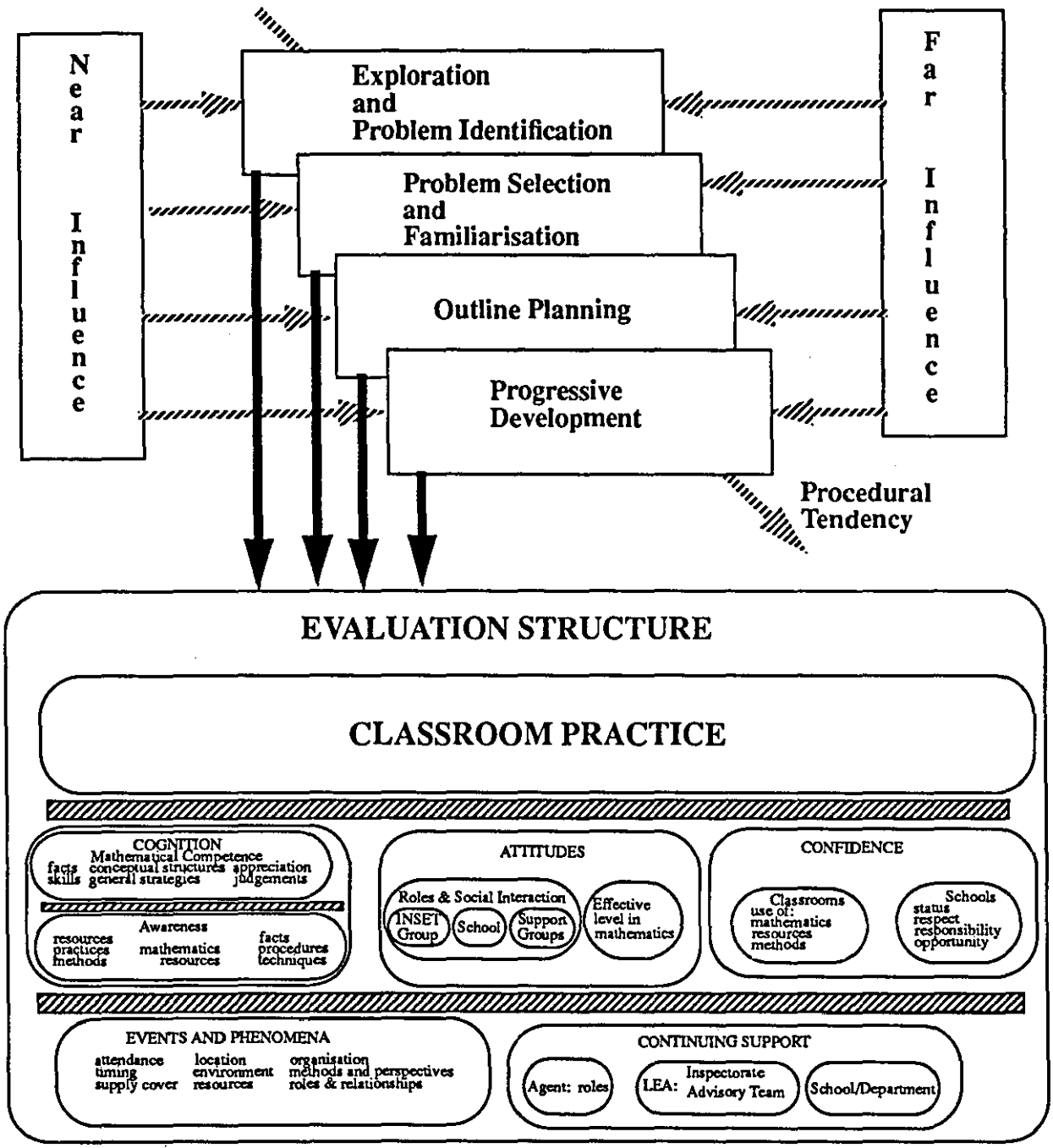
This model shared certain characteristics with Walker's model but with some significant differences. Among these was the description of the four phases in the first part of the model. There was '*significant overlap between the four phases and elements of each phase may be conducted concurrently, or in an order which is heavily dependent on prevailing situations and observed events*' (Armstrong, 1990), though roughly progressing in an order termed 'procedural tendency'. Armstrong's model also recognised that the beliefs and preferences of the developers did have an effect on the curriculum planning and design though with a slightly different emphasis from Walker. He identified 'near' and 'far' influences, which he suggested changed continually as the development proceeded.

The term 'far' influences was used to describe the influences that came from organisations or systems. 'Near' influences were those created by the individual involved in the development themselves, their beliefs, interests, preferences and experiences.

5.3 The planning and design of the Mathematics course for first year Engineering undergraduates with non-GCE A level entry qualifications

Analysis of data gathered in this research has found that the rational models for curriculum development do not fit that data very well. Instead, analysis will build on the theory of D. Walker (1971) and P. K. Armstrong (1990) but allowing the researcher's own theory to

Figure 3: A 'Naturalistic' INSET Model : P.K. Armstrong , 1990



evolve from the data. However, the latter theory could not help being influenced by the theory from the two models especially that of Armstrong's. Since the researcher did not undertake the research until the course was already in the implementation stage, the theory will be focused on the design and implementation phases of the curriculum. Information about the early stages in the planning of the course could only be inferred from interviews with the members of staff concerned and has, therefore, not been used to any significant extent in developing theory.

5.3.1 A naturalistic model of the 'BTEC' Mathematics course

One of the aims of which guided the theoretical search was to refute or support the naturalistic models of Walker (1971) and Armstrong (1990). As the data was collected and analysed the model which emerged supported the main framework of Armstrong's model although the analysis suggested certain modifications to that model, particularly with respect to what is termed 'far' influences. These appeared to have played a much more significant role in the design and development of the 'BTEC' Mathematics course than Armstrong's model would suggest. This researcher believes that this aspect is one of the important findings of her research.

Armstrong's model was developed mainly from studies of in-service education courses (INSET) for teachers, hence modifications might be expected if it were to be applied to other curricular developments. For this reason and to distinguish it from the researcher's model, his model shall be referred to as the INSET model.

The 'BTEC' Mathematics course model is presented in two parts. The first part represents the 'phases' of design and development of the Mathematics course. The second part concerns the evaluation structure, which the research suggests depend heavily on the judgement of the teacher of the course.

The research data suggested that the developers of the Mathematics course were constantly reviewing their past experience, either

collectively or singly. This review appear to be a significant aspect of the process as they search for new ways and methods of teaching Mathematics to the BTEC students. The research data suggest that the existence of major difficulties in the teaching and learning of Mathematics for such students was widely accepted and that the problem had been acknowledged to exist for the last twenty years. The focus of the planning and design was on how best to teach and present the Mathematics. Throughout, what were termed as the 'near' and 'far' influences played a definitive role in shaping the final decisions. The intensity of either or both of the 'near' and 'far' influences fluctuate during the different phases but a finding of this research indicate that the 'far' influences appeared to play a much more significant role in the design and development of the BTEC course than the INSET model suggest.

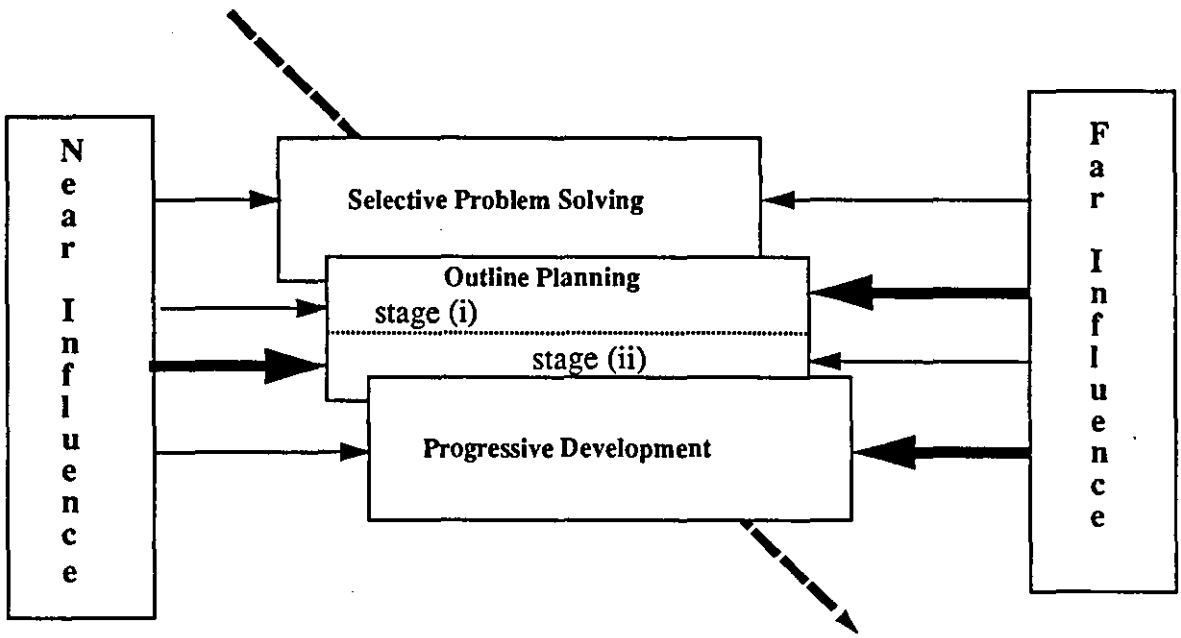
5.4 Part 1: The Three Developmental Phases

The first part of the model (Figure 4) is described in terms of phases of development and consist of three phases:

Selective Problem-solving
Outline Planning
Progressive Development

This particular part of the model has clearly modified Armstrong's four phase Development Model. However, as mentioned, the researcher was not party to the initial discussions in the setting up of the course thus the model described will focus on the design and implementation phases of the curriculum. The phases described are roughly in the order shown (Figure 4), which has been termed Procedural Tendency. The phases do not necessarily follow in sequence as there is a tendency for the phases to overlap or for them to occur concurrently, depending on the prevailing situations.

Figure 4 : **Part 1 : The Three Phase Developmental Model**



5.4.1 Phase 1: Selective Problem-solving

The course was described by many of the staff interviewees as an initiative of Dr. B of the Mathematical Sciences Department. They spoke of the many discussions that he had conducted with them (*vide supra* 4.3). Even Mrs. A, who taught the course, implied that Dr. B was mainly responsible for "getting the course off the ground".

(Extracts from interview, Mrs. A, 14/6/90)

> *"What we're planning to do a little more during next year....Dr. B has got this in hand and with some of their departments....what we're planning to do is try and bring all the BTEC students together....."*

The various members of staff interviewed had very strong opinions (*vide supra* 4.3.2) about the mathematical abilities of the BTEC qualified first year undergraduates and about the Mathematics in the BTEC courses. Most of the opinions were strongly in agreement that, since the BTEC students had less time for Mathematics in their courses as compared to the GCE A level Mathematics courses, they were at a disadvantage when it came to the amount of Mathematics that they had managed to do and the depth which the topics were dealt with. They agreed that similar topics were covered in the general BTEC syllabuses as in the GCE A level syllabuses, although they conceded that the many available syllabuses in GCE A level Mathematics were quite varied (*vide supra* 4.3.2) as well. They quoted their past experiences, both first-hand and those shared with their colleagues, with similarly qualified students as a basis for their views.

It appears that in the first phase of the developmental model, there was little attempt to formulate precise objectives for the course, though the general aims of the course was stated. It was clear that the process undertaken did not follow any of the procedures described in the classical models. The course was frequently referred to as an experiment in teaching 'BTEC' qualified students, in the sense of being yet another attempt at helping students with non-GCE A level mathematical background cope with the Mathematics at degree

level. Data from the observations of the course showed that though the majority of the students had BTEC qualifications, there were also others with other non-GCE A level qualifications. Further, nearly all the entrants with non-GCE A level qualifications were at first, advised to follow the course. Data gathered also suggests strongly that the course design was evolved based mainly on comparisons with the experiences of other efforts in the past (*vide supra* 4.3.3) at LUT. Efforts was focused on determining suitable methods to teach Mathematics to the identified group of students within the constraints of the 'far' influences.

Thus the first phase did not follow any strict guide-lines but it would appear that every participant involved was directed by what has been termed 'near' and 'far' influences. The 'near' influences refers to the beliefs, preferences, experience and current academic/research interests of the developers. Whereas, the 'far' influences accounts for the professional demands, administrative and organisational demands, the higher education system and financial constraints.

The research data on the course development appeared to fit quite closely Armstrong's model although there were some slight differences which were peculiar to this research. The procedure that was carried out in determining the design of the course appears generally to follow the first two phases of the INSET model with the 'near' and 'far' influences exerting nearly equal dominance in progressively focusing and shaping the final course design. In the INSET model, Armstrong identified a process of identifying candidate problems. In the 'BTEC' model, there was strong agreement of what the problems were and the concentration was on selecting the possible solutions which could satisfy the demands exerted by the near and far influences. Thus there appears to be a more focused first phase and as such this did not truly fit into Armstrong's description of the INSET model phase 1 and phase 2. Quick decisions seems to be necessary and further influenced the process of the BTEC Mathematics course design. Another peculiar aspect to this course implementation, is the strong influence of one individual in bringing about the changes to the course. It has been reported (*vide supra*

2.2.2) that LUT had plans to introduce modularisation in the students' courses in the near future. Such was the concern of the staff with the BTEC students' mathematical performance, that, in the light of impending modularisation, it was considered prudent to introduce the separate course immediately in order to help the students in the meantime.

The researcher has described the first phase as Selective Problem-solving, as it appeared that the developers had selected problems that are amenable to solutions within the demands of the 'near' (which again had roots firmly embedded in the strength of past experiences) and 'far' influences. A diagrammatic representation of the phase is given in Figure 5.

Analysis of the data supports firmly Walker's argument on the crucial roles of beliefs and values but suggests that theory requires Armstrong's depiction of the roles these values and beliefs play throughout the progress of the development. Walker's platform has components which he describes as *conceptions* (beliefs about what exists and what is possible), *theories* (beliefs about what is true), *aims* (beliefs about what is educationally desirable), *images* (specifications about what is desirable) and *procedures* (specifications of desirable courses of actions). His idea of the platform suggests that it functions as a foundation on which the development of the curriculum process is based, thus it appears rigid and unchanging. Analysis of this research data concurs with Armstrong's suggestions that the beliefs and values of the developers of the 'BTEC' Mathematics course constitutes influences rather than a platform. The research data further suggests that the strengths of the influences continually change during the different phases. Consequently the changing intensities of the 'near' and 'far' influences shape the decisions made by the developers.

5.4.2 Outline Planning

The analysis suggests that the developers began to prepare an outline plan or a possible working solution in this phase. In fact, the

general form of the working solution might have appeared earlier or might even have directed the discussions. However, it is in this phase that the outline plan is refined. Where the 'near' influences subtly direct the developers in their considerations of the problems, it is suggested that in this phase, the 'far' influences are closely examined to finally construct a viable course design. Thus, the analysis suggests that the 'far' influences plays a most significant role in this phase. However, the researcher has also found that in this curriculum development, the Outline Planning phase was carried out in two stages (Figure 6).

In the first stage, in which he played a prominent role, where Dr. B initiated and conducted various discussions with other teachers of Mathematics responsible for the teaching of Mathematics to students in the Engineering Departments and concerned staff in the Engineering Departments (*vide supra* 4.3). From these discussions, it would appear that the general outline of the course was decided. Decisions were made on the setting up of a separate course, whom amongst the students were to be placed in the course, the number of teaching hours assigned to the course and a general indication on how the students were to be taught. At this stage, the far influences (the Engineering Departments constraints on Mathematics teaching time, the requirement that the course would not involve extra Mathematics teaching staff, administrative and financial constraints) appeared to exert a strong influence in shaping the decisions. It is suggested that these influences were in fact considered by the designers so that the course design would be acceptable to the appropriate authority.

In the second stage, the responsibility for the course was transferred to Mrs. A. In fact, observation of the development suggests that each teacher of the several Mathematics courses for the various Engineering Departments was expected to function independently and was responsible for the curriculum development and progress in its implementation. Mrs. A was, alone, responsible for decisions about the syllabus details, teaching strategies, teaching methods, course materials to be used, in fact, all the planning and implementation of the students' learning experiences within the 'BTEC'

Figure 5: Phase 1: Selective Problem Solving

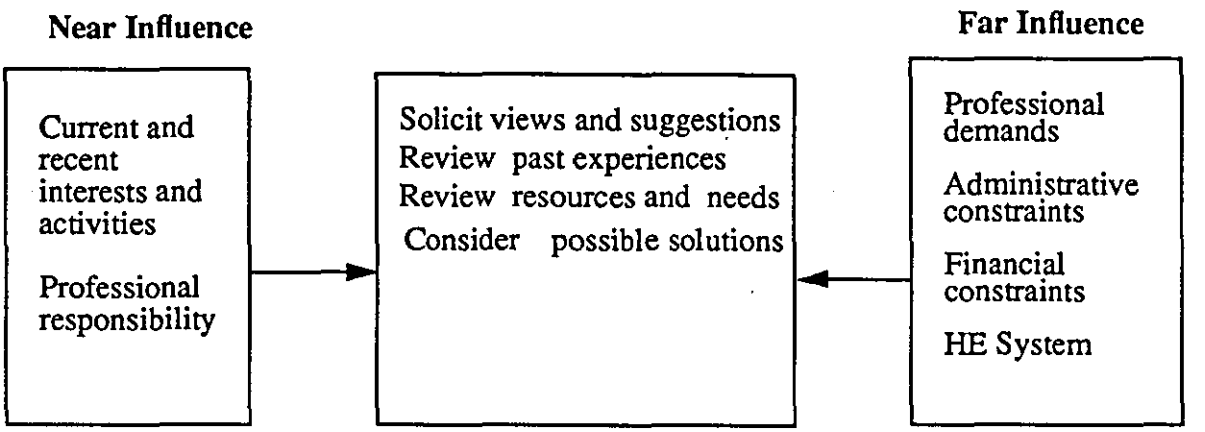
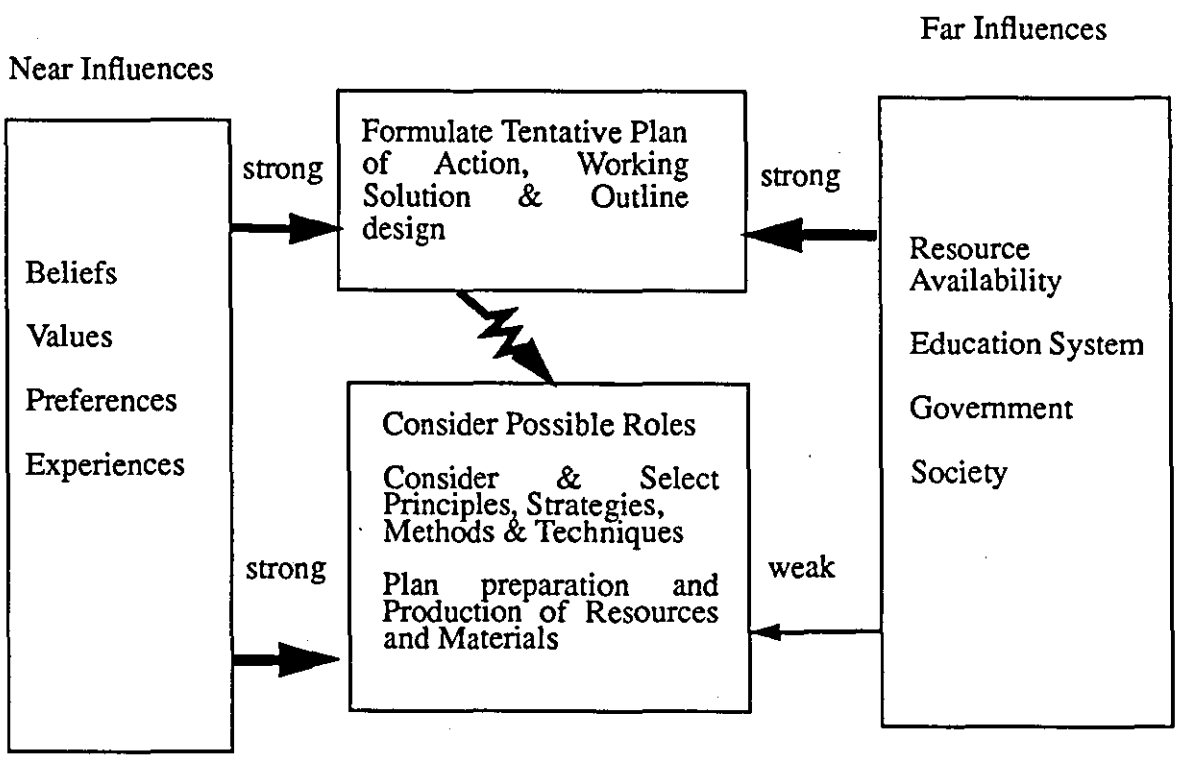


Figure 6 : Outline Planning



course. The general Mathematics syllabus itself was inherited from previous years. It is clear that the confidence and expectations of the professional abilities of a university teacher is very high. The higher education system bases its operations on professional integrity, respect, trust and some degree of autonomy on each teacher in teaching the Mathematics course. Each of them could develop their course as they saw fit.

The classical prescriptive theories and models of curriculum theory, therefore, do not fit this particular situation at all well. In this second stage then, obviously, the near influences were very strong. Mrs. A designed the course based on her past experience, her beliefs on what were the students needs and how best to help them with their difficulties (*vide supra* 4.3.2 and 4.5.2).

In a discussion on the research analysis held with Mrs. A, she commented,

(Extracts from interview, Mrs. A, 27/8/92)

> *"Sometimes, of course, you're just very constricted about how much you can change and um... you have..I don't know whether it's an advantage or a disadvantage, but you see that when you're teaching a course and in particular if you've taught a course for several years then you see it from beginning to end (R: you mean..) and you know just how last year's students reacted (R: yes) and how they changed often from beginning to the end (R: yes) in their attitudes whereas of course, (R: yes) they're right in the middle of it, they can't see it through as a whole and er..things that they complained about at the beginning (R: yes), by the time they get to the end, they have realised that those things were all right (laughs) (R: yes and you know that..) and you know that will happen you see umm..if you'd listen to your students completely and went along with them you'd probably never teach more than the first term's work simply because you will slow down to the rate of the slowest and the most complaining and er.. you would concentrate on the bits that they thought was..was important (R: hmm) at the time and you'd never cover what you wanted*

to do (R: inaudible) hmm..I don't mind leaving little bits of the syllabus but by and large you can't leave chunks out (R: no..) of the syllabus.."

The researcher has found that not only the near and far influences constantly changed during the curriculum development but the intensity of the influences fluctuate during the different phases as the different individuals take over the lead in the curriculum process.

5.4.3 Progressive Development

The Progressive Development phase attempts to describe the progress of the course during its implementation and the complex situation in which teaching and learning occurs. The INSET model for the Progressive Development consisted of a spiral of steps, each of which was composed of planning, action and the evaluation of the results of that action. In the BTEC model, the researcher has built on the INSET model to take into consideration the almost random and strong effect of the 'far' influences which caused disturbance and enforced revision of the teaching plan (*vide supra* 4.5). These variables are controllable if adequate preparations are made. In fact, the researcher suggests that Armstrong's model could only be arrived at if the variables identified here could be controlled.

It was observed that the most significant revision to the plan of action was brought about by strong 'far' influences. These 'far' influences, which consisted of changes occurring in certain Engineering Departments, had enforced changes to the teaching plans. Changes were made, not out of choice, review and analysis, but out of necessity and due to pragmatic considerations. A degree of unpredictability has to be built into the model as these events, usually unaccounted for by the Mathematics teacher due to poor and insufficient information flow, disturbed the planning and the progress of the course. Furthermore the events occurred sporadically over a period, suggesting perhaps, a random perturbation factor might usefully be included in the model (Figure 7).

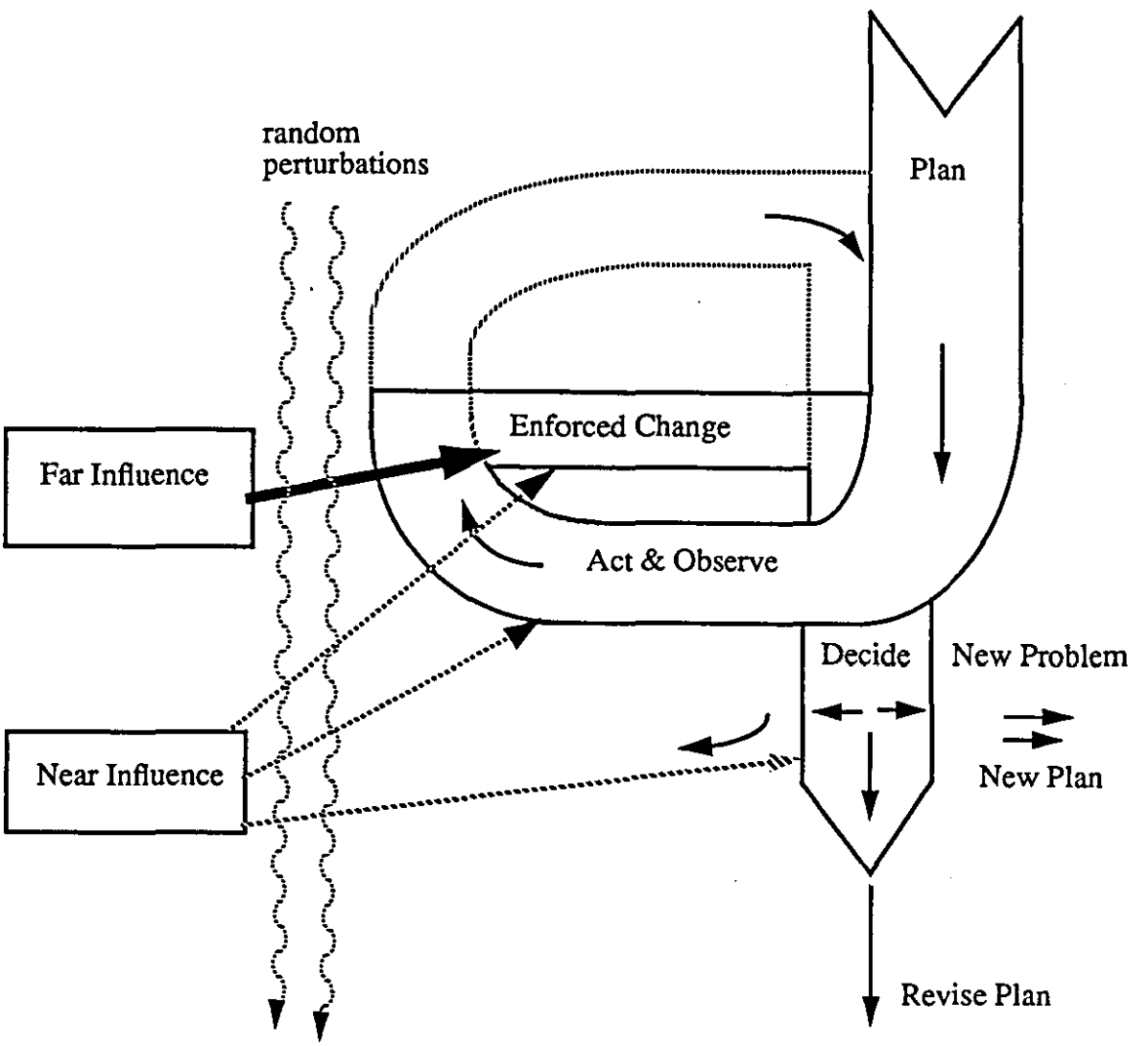
There is a further peculiarity of these research findings which differs with the conclusion of the INSET model. The INSET model described a situation where the individual was simultaneously working with a number of development spirals which was termed sub-spirals. The development of the sub-spirals were guided by the Outline Plan and their aggregation was modelled by a super-spiral. The situation was described thus,

> *"In some ways the Outline Plan seems to act as a 'genetic' code, so that developers undertake sub-spirals in such a way that they interact and aggregate to a particular super-spiral."*
>
> (Armstrong, 1990)

In this research, it was observed that a number of development spirals were simultaneously undertaken by the various staff members concerned with the teaching of the students, however they do not appear to be guided by the Outline Plan nor do they aggregate towards a super-spiral. The observed conclusion was that although the decisions made within the sub-spirals do affect the particular development and progress of the BTEC Mathematics course, there was no apparent reference to the Outline Plan. It was these particular circumstances which manifested as the 'far' influences which disrupted much of the progressive development of the BTEC course.

Analysis shows that the far influences were very strong and these compelled the teacher to constantly revise and modify her schedule. For example, she did not have enough information about the students activities within their specific Engineering Departments in the first term. She did not know that the Civil Engineering students were not coming in during the first week, when the Manufacturing Engineering students were to have their "Engineering Applications Week" or when the Electrical students were having a "Fallow Week". She was also told later that the Electrical Engineering students were to go back to their parent Department for Mathematics in the third term. These were among the most significant events that affected the whole class as it disrupted the teaching schedule that was planned. There appeared to be numerous problems, lack of administrative support and information, and poor communication between Mrs. A and the

Figure 7: Progressive Development Phase



Engineering Departments. There was also the added difficulties of teaching Engineering students from the various Engineering disciplines, who at one time or the other, required emphases on different topics in the syllabus. These problems brought about many of the revision to the teaching schedule (*vide supra* 4.5)

During the progressive development phase, the 'near' influences was observed to be more stable than the 'far' influences as Mrs. A had very firm beliefs as to how the students should be taught and was not easily influenced by the students' sometimes emotional responses. However, this does not imply that she was insensitive to the students' needs and difficulties. Necessary changes was made to her presentation methods, if and when required. It was clear that she had to depend on her observations, analysis of the situation, and past experience in an attempt to form judgement.

5.5 Course Evaluation

The researcher decided to look at the course evaluation from two different perspectives, that of the developers and that of the students. It was felt necessary to present the evaluation separately as these evaluation processes had different impact on the curriculum development. The developers had, by far, the most authority and influence on the curriculum development process. Although the views of the students were sought by the teacher, either informally or formally, through various questionnaires, their evaluation was usually tempered against the value of the teacher and developers past experiences of the course and students behaviour.

5.5.1 Developers' Evaluation

A main characteristic of this particular curriculum development is the near absolute autonomy and independence of the lecturer concerned in developing and evaluating her course after the responsibility of the planning of the course was transferred to her in the second stage of the Outline Planning phase.

The data suggests that the developers contributed to the evaluation process by identifying generally the categories to be evaluated. These were conveyed to the lecturer who would be responsible for the course through discussions. They appeared to constitute general aims of the course. Interviews with staff suggest that these aims were perceived in the following terms.

(1) building the confidence of the students in using their Mathematics
(2) developing skills in students
(3) guiding the students towards self-learning
(4) improving the knowledge of students.

As the development itself was not firmly based on the rational approach, a wholly quantitative measurement based evaluation was not possible. However, examination results were used by some interested parties, particularly Engineering Departments, as one of the ways to indicate the effectiveness of the course as well as a means of assessing student achievement. Nevertheless, the developers themselves appeared to desire more general outcomes (such as: increase in confidence, appreciation of Mathematics) although they did not suggest the means for such an evaluation. The focus of the course evaluation by the developers seemed to be the improvement of the course, but that evaluation appeared to be an on-going process which is entrusted solely to the teacher of the course. This means that the evaluation tended only to serve the teacher concerned and was seen by her as adding to her experience for future considerations when designing and implementing Mathematics courses.

(Extracts from interview, Mrs. A, 28/7/92)

R: *"So even in the previous years, every maths lecturer taught their own group were quite actually free with their own group, I mean, there was no report or anything that was required from them to give to.."*

A: *"No, in fact there is no evaluation* (laughs) *for many years, it's only been in the last two years.."*

R: *"so a lot of the evaluation is dependent upon your personal I mean you personally evaluate the course* (A: Yes..) *and and .."*

A: *"I think you always evaluate er..your course er..in the sense ..I mean your examination results of course do that for you to a certain extent but I think you always look back on a course and you say what went well, what didn't go well..do I need to spend more time on this, do I need to spend less time, do I need to cut something out, um. is there anyway in which I can teach that ..I..am I better to produce more worksheets, more handouts.."*

Mrs. A employed various means in evaluating the course which included the following:

(1) informal students feedback - these were students responses offered or elicited during lectures, tutorials and surgeries;
2) formal students feedback - which were sought out using questionnaires;
3) her own judgement and past experiences;
4) examination results.

The importance of using students' feedback as a means to evaluate the course was usually considered within the framework of the lecturer's past experiences and judgement because of the wide range of responses received from students (Appendix 8).

(Extracts from Interview, Mrs. A, 28/7/92)

"Only an overall view of students' response that is reliable taking..response over the complete year and far as possible (R: inaudible) *from the whole population* (R: inaudible)*...individual responses are so often useful in that they highlight something that has gone wrong* (R: for that person, I think rather than ..) *umm yes and maybe for other people who hasn't said it, you have to take notice of an individual response but you have to see it in the context of the whole because sometimes that individual response highlight a problem and you can do something about it sometimes it highlights a problem that you can't do anything about it, it's beyond your control* (R: inaudible) *like* (inaudible) *saying well you just can't you know cover far too much ground in the year, maybe that is true but*

you can't do anything about it because that's beyond your control..(R: yes)"

It appeared that the lecturer's own observations and judgement were the most important instrument in evaluation.

(Interview transcripts, Mrs. A, 28/7/92)

R: *"For instance, I noticed that, you'd put...I mean that Dr. B talked about building the confidence of the students and building the the knowledge base and there was lot of er..I suppose the general term would be like the pastoral care that you had to give out to the students, advice about how they're supposed to study* (A: hmm) *or even personal advice on how they're supposed to cope with university* (A: yes) *and er..I wonder whether that's an important factor of your work all the time I mean not just this this last year's this year's and the previous years..*"

A: *"I think I think that is...what I would like to feel that you can say at the end of year is that for most students they know a little bit more Maths and they can use the Maths that they do know a little bit more confidently* (R: yes) *and that they have..that they gained some study skills and that they can.....and and the enjoyment I think is another thing that I'd like to feel* (R: that they enjoyed the course) *no not necessarily that they enjoyed the whole course I mean er.. in particular if it's a labour for them then enjoyment is a wrong word for it* (laughs) *and if they find it very hard but if they can begin to see how Maths is used and begin to start enjoying learning some Matns and.....*(R: *it's very difficult isn't it to to gauge the confidence I mean ..) when you get your evaluation sheets back you see one student would say, "I have really gained in confidence this year, I'm very happy about the course"* (R: yes) *and say another student who've been through exactly the same course and perhaps started with exactly the same qualifications say the exact opposite of that now have you succeeded or have you failed or have you done neither..(laughs) you know you just don't know at the end of the day, you can only.. every year build on last year's*

response and hope that you can fill the gap for somebody else's a little better next year and.."

5.5.2 Students' Evaluation

The students evaluation of the course is harder to summarise as there was such a large variation in responses (*vide supra* 4.6). In some of the cases, their responses were also dependent on their personal feelings toward the course, the teacher, their departments and toward their new lifestyle on campus generally. The researcher, however, has observed that the students, were generally quite resilient and adaptable to any demands that the course presented. They complained but usually, they will be able to bear whatever changes or adjustments made to the course.

From analysis of the data gathered, the students appeared to evaluate the course based on some general categories such as:

1. examination results
2. inter-personal communication
3. organisation and administration of the course
4. presentation of materials.

During this course, the students' views were actively sought out by the teacher concerned both informally and formally. The teacher had develop a good rapport with most of the students, and this relationship was greatly appreciated by the students. Their contribution to the course evaluation will add to the experience bank and some will be considered in future design considerations.

5.6 The Overall Evaluation Structure for the BTEC Mathematics Course

The data suggests that improved students' capability and competence in Mathematics was the main outcomes that the developers seek from the course. However, some importance is also placed on the students' performance in the end of year examination. The second part of the

BTEC Mathematic course model describes the evaluation as a set of categories and sub-categories. In this respect, the researcher has based the model strongly on Armstrong's Evaluation Structure model for INSET. The researcher, however, has decided to separate the evaluation carried out by the developers and the students, as the main participants of the course. The categories identified are slightly different but this is recognised by the INSET model as it allows for different categories and sub-categories to be considered in the light of the prevalent conditions.

The overall evaluation structure depends on the support which the categories described below provide for each other. Each category is made up of mutually dependent and supportive sub-categories. Data from this research suggests that the teacher was the most important evaluator. She tended to be the one who finally considered the various components of this structure (components made up of categories from the developers' and students' perspectives), but she always did so by looking at each component in relation to the whole structure. Since the nature of the categories except for the examination results, are not easy to evaluate objectively, so much depends on the judgement of the teacher concerned. Also, it should be noted that it was not possible to predict the development of these categories from the outset of the development of the course.

It is possible to identify the main categories in the BTEC Mathematics course evaluation structure which consists of:

Developers:

(1) Increasing students confidence
(2) Building students cognition
(3) Enhancing students attitudes
(4) Examination performance

Students:

(1) Examination results
(2) Inter-personal communication
(3) Organisation and administration of the course

(4) Presentation of materials

These are illustrated in Figure 8 below.

5.6.1 Developers categories

1 Confidence

This category relates to the confidence of the students in handling mathematical data, information and problems. This is sub-divided:

(i) confidence in the Mathematics class
(ii) confidence in handling the Mathematics in other subjects

Both sub-categories relates to the confidence of the students in using the Mathematics (for example, new topics, unfamiliar problems) as well as confidence in the use of resources such as computers, calculators, unfamiliar textbooks.

Evaluation concerns the degree which the students' confidence has improved.

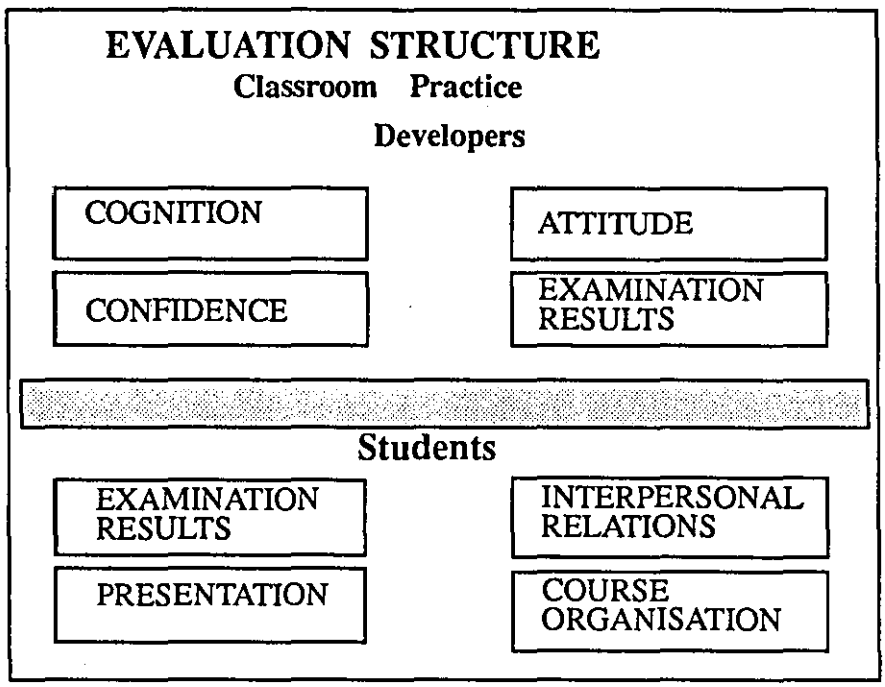
2 Cognition

This category refers to the acquisition of mathematical knowledge, enhanced mathematical skills and an appreciation of the subject's importance. In short, the degree of students' competency in Mathematics, not only in the Mathematics course but their ability to relate to the Mathematics in other subjects in the Engineering course.

3 Attitudes

This category relates to the students perception of their relationship with each other, the teacher and their department as well as toward Mathematics. For example, a majority of the students entered the separate course with a good attitude toward the design of the course

Figure 8 : **The Evaluation Structure**



but with a more varied feeling toward the subject itself. It was also observed that even after some students found the course disappointing, they were still kindly disposed toward the teacher herself.

4 Examination performance

All the three categories described so far are related to the improvement of the students' cognitive and affective levels in Mathematics. However, the fourth category, examination performance, shows that a somewhat measurable indicator of improved students' ability is also involved. Though it was recognised that a student could have improved in all the previous three categories but not necessarily achieve a brilliant examination result, good grades was regarded by the Engineering Departments as a means to indicate competency.

It can be concluded that the underlying concern throughout the evaluation is student development. However, since innovation is usually pushed through by individual's interest or beliefs, the evaluation will also serve to determine the continuation of a particular course. The evaluation definitely will be added to the wealth of experience of the teacher and will influence future design and implementation decisions.

5.6.2 Students' categories

1 Examination results

Data gathered has shown that the students have, from the outset of the course, been most concerned with examinations and the results that they need to obtain to progress through to the second year. They plan their learning and studying, organise their revision, to accommodate the subjects that will contribute the most to their success at the end of the year. They appear to develop a very

practical and realistic attitude toward the course. They certainly decide that they need to pass the examinations.

2 Inter-personal communication

This category concerns the students' need to be able to relate to their teacher at a personal level. They do appear to evaluate the course based on the relationships they build with their teacher.

3 Organisation and administration of the course

The students appreciate an efficient and smooth running of a course. They tend to evaluate the course based on how it is organised as they are at the receiving end of any changes and modifications.

4 Presentation of materials

This category relates to how the teaching material is put across to the students as well as the teaching methods used (lectures, tutorials, laboratory sessions, textbook).

In this course, there was some complaints about the lecture notes but an overwhelming appreciation over the textbook chosen for the course.

5.7 The Overall Naturalistic 'BTEC' Mathematics Course Model

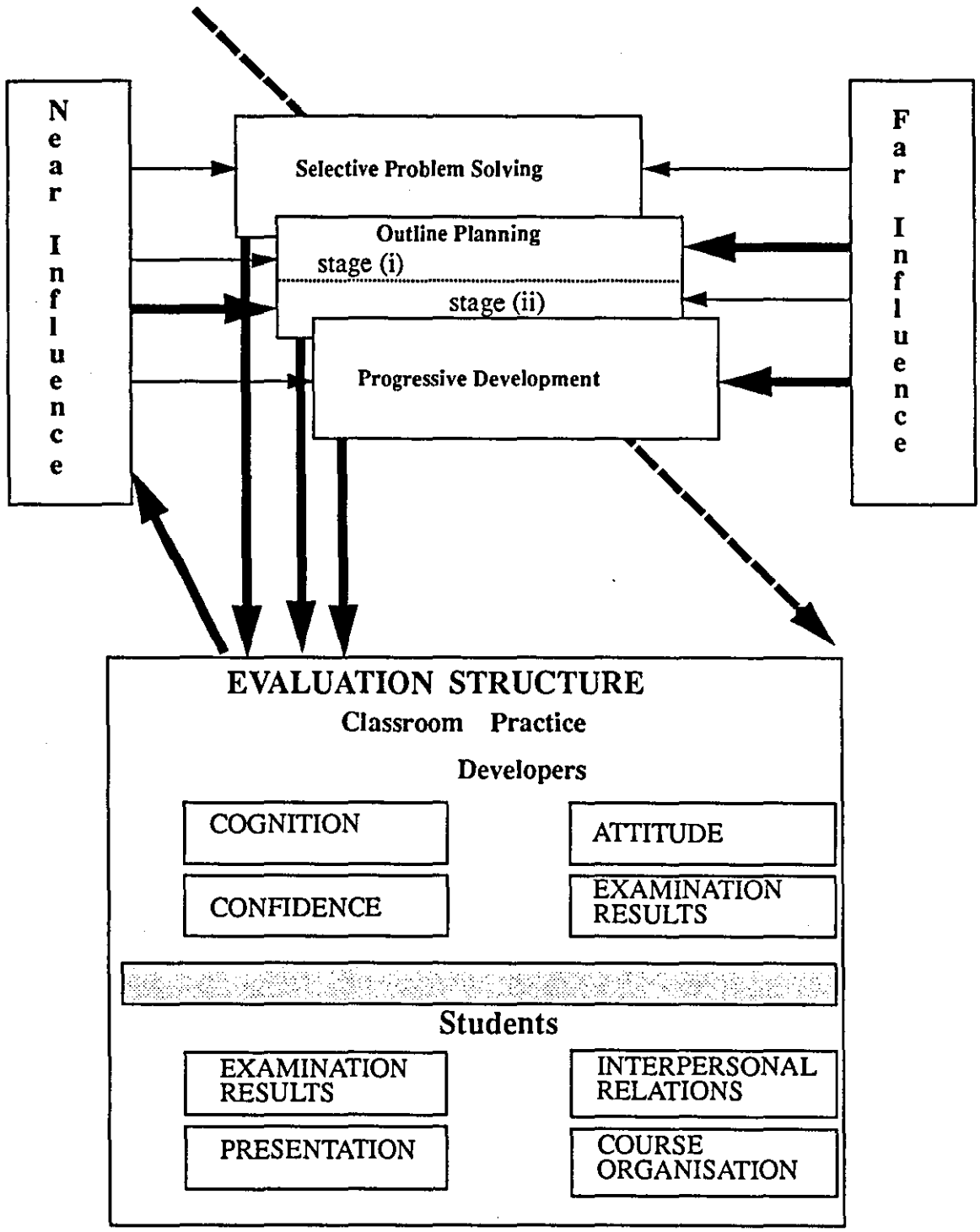
The combination of the two parts of the model (Figure 9) represents a more complete description of the 'BTEC' course development. It should assist in understanding how the course was designed and developed and how it was evaluated. In order to evaluate effectively a curriculum development, it is necessary to understand the processes which it has gone through. It is difficult to judge a programme in terms of success or failure as any particular programme is always a mixture of both. Data gathered in this research testify to this circumstances. Weiss and Rein (1969) in

commenting on an objectives model evaluation of a social programme, concluded that:

> *"...a far more effective methodology would be much more descriptive and inductive. It would be concerned with describing the unfolding form of the experimental intervention, the reactions of the individuals and institutions subjected to its impact, and the consequences, so far as they can be learned by interview and observation, for these individuals and institutions. It would lean toward the use of field methodology, emphasising interview and observation, though it would not be restricted to this. But it would be much more concerned with learning than with measuring".*
>
> (Weiss and Rein, 1969)

The two parts of the model are mutually dependent. The activities of each phase of the Curriculum Development Model has contributed to the construction of the Evaluation Structure. In turn, the Evaluation Structure has modified or contributed to the nature of the near influences, which has considerable bearing on the process of design, development and implementation of the 'BTEC' Mathematics course. In this respect, the model represented here is actually based firmly on the general framework of Armstrong's INSET model. However, data gathered in this research also suggest that the impact of the far influences is greater in enforcing changes to the course implementation. The INSET model does emphasise the changing nature of these influences but did not identify the intensity of the changes which the model presented here has taken into account (*vide supra* 5.4.2).

Figure 9: The Naturalistic ' BTEC' Mathematics Course Model



5.8 Research Conclusions and Recommendations

5.8.1 Conclusions

This research had looked into the planning, implementation and development of a particular curriculum innovation in providing a Mathematics course for students with non-GCE A level entry qualifications. Other research (vide supra chapter 2) that has looked into the provision of Mathematics to undergraduates in Engineering courses has focused on the course contents, the teaching methods and the evaluation of students mathematical ability by scrutinising the subsequent performance of the students in tests or examinations. In adopting a qualitative research perspective, the researcher hopes to provide a studied and detailed description of the Mathematics course as it progressed throughout the year. Through this, it is hoped that a better understanding of the prevalent conditions and problems associated with the course implementation and its development might be achieved. There was a need to evaluate the effectiveness of the course design and to identify the factors that could influenced the design and implementation.

Observations and data gathered in this research has led to the conclusions that curriculum design did not depend only on the course aims. The form of the curriculum was not deduced or brought out by considering only the given facts on the problem at hand. A host of other factors had influenced the design including personal beliefs and preferences, administrative, organisational and financial constraints. Such rational considerations were important in the formation of the final form of the design, in finding the most appropriate design and in deciding the means of implementation. In the observed process, it confirmed the finding by Walker that the '*logical essence of curriculum development is practical reasoning*' (Walker, 1975).

Another finding in this research was that the curriculum was loosely based on its original aims which themselves were loosely formulated and tentative. In its implementation it became a continuously evolving curriculum process as the teacher used her own judgement, past

experiences and observations in trying to improve her teaching methods, course presentation and trying to gauge the needs and difficulties of the students. It was clear that she had to deal with a set of constraints that frequently changed due to the near and far influences. Though it was observed that the near influences were quite stable, several external considerations had forced changes to be made to the curriculum implementation. The process truly became a creative endeavour but this was governed by rational considerations of the practicalities of the teaching situation.

It was apparent that the process of curriculum development in this particular research did not rest on any particular curriculum theory but was evolved mainly from collective past experiences of the staff involved in its planning process. Its evolution also depended on far influences consisting mainly of administrative and financial considerations.

From observation of events and the behaviour of participants, it was difficult to identify how the tentative course aims (mainly, to increase knowledge and confidence in the students) were translated into practical teaching and learning situations. There was little evidence of any attempts to formulate an evaluation process to assess the attainment of the aims. What was observed was that the only formal evaluation of the students mathematical ability was through the final examinations. The teacher however, evaluated her students personally through informal students feedback as well as relying on her judgement based on her past experiences.

5.8.2 Recommendations

It would be more helpful for future considerations of curriculum design if these research findings were recognised and taken into account. A recommendation of this research is that efforts should be made towards documenting all the set of factors and circumstances surrounding a particular design of a curriculum innovation. This will assist in subsequent design changes and evaluation. It is not the purpose of this thesis to define the specifics of such a document,

merely to express the need for such work as it was clear that there was a heavy reliance on past experiences.

Although this research would not suggest that a classical prescriptive model of curriculum design should be adopted, it does recommend that developers should be aware of the 'near' and 'far' influences which affect their actions and decisions. They should also recognise that an effective communication system needs to be established to effect some control in these influences and to avoid destructive perturbations in the development of courses. Designers should also be encouraged to review those aspects of evaluation which, not only they, but their students consider to be of vital importance. This process should be directed towards widening the purview of evaluation beyond mere examination results. Likewise, student feedback should be considered such an important factor in curriculum development that it should be gathered by methods which would seek validity and reliability in reflection of good research practice. This necessarily means that feedback data must be gathered by pluralistic methods and analysed carefully. Too often student feedback is gathered by limited methods and is subject to rather superficial analysis. In parallel, views and opinions of staff should be collected and interpreted in a more rigourous fashion than they often are when a curriculum is designed and developed.

5.8.3 Further Research

It has been necessary to leave out a substantial amount of data in order to produce this thesis. Much of the data which relates to the beliefs, behaviour, learning strategies and the patterns of the developing relationship between students and the teacher could form the basis of further research looking at the learning behaviour of mature students. The data could also form the basis of a programme to research further the importance of Mathematics in Engineering and consequently to review the syllabus for the teaching of Mathematics to Engineers, particularly in light of advancements in Technology.

Documentary evidence and primary data of other mathematical provisions and curriculum developments could be analysed, to continue the generalisation and testing of the theory and model developed here. Such retrospective generalisation was recommended by Stenhouse (1978) in advocating a research perspective and methodologies based on the work of historians. Indeed Walker (1971) adopted such an approach in developing his Naturalistic Model of Curriculum Design.

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Appendix 1

Brief history of the expansion of Loughborough University of Technology.

1909–1915	Loughborough Technical Institute
1918–1939	Loughborough College and period of expansion
1939–1945	Second World War. Loughborough College ran courses with reduced intake on a war-time footing.
1945–1952	Lougborough College and its break-up
1952–1966	Loughborough College of Technology to Loughborough College of Advanced Technology
1952–1977	Loughborough College of Education
1966–	Loughborough University of Technology

Appendix 2

Interviews with lecturers from nearby colleges

1. LC

Interviews were conducted with the lecturers who taught various non-GCE A level Mathematics courses at 2 nearby colleges. These were BTEC courses, Open Learning courses and ACCESS courses. It was hoped that the researcher would be able to identify qualifications other than the BTEC ONC/OND and HNC/HND which students would have had as entry qualifications. The interviews were also needed to find out and understand the educational background of the BTEC qualified entrants.

The researcher's first interview was with a group of lecturers who were going to launch a new ACCESS course in Mathematics and Science. As this was the researcher's first interview, she had to consider the various interviewing techniques and decided that it would be conducted as a focused interview (Powney & Watts, ...). This meant that the researcher has set some topics for discussion and would focus the interview around these topics. The method chosen to record the data was by handwritten notes.

The meeting took place on the 12th March, 1990. The lecturers were Brian (Head of Science Department), Mandy, Moult and Ruth (lecturers involved with the planning of the various preparations for the courses). They were going to have a meeting about the progress of the preparations for the launching of the courses. The researcher had not plan for a group interview but the opportunity arose as she was invited by Mandy to attend the meeting. She would be given the opportunity to interview the lecturers after the meeting.

The course, named Springboard, has not started but was expected to commence after Easter, 1990. It was a joint collaboration between LC and Nottingham Polytechnic. The ACCESS courses would be open to anyone and there were no formal entry requirements. Students who would have completed the courses successfully were supposedly guaranteed a place in a science-based or teaching Degree Courses at Nottingham Polytechnic in areas such as:

(1) BSc Courses: Applied Biology, Applied Chemistry, Combined Sciences, Mathematics for Information Technology
(2) B.Ed Courses: Primary School Mathematics and Science, Secondary School Mathematics and Science.

In the course of the meeting, it was made clear that students on these courses would not be taking up degree courses with a strong mathematical content such as Engineering. As the researcher was more interested in courses that could enable students to enter Engineering courses, it looked as if the ACCESS courses under discussion would not be suitable. However, Brian and the others made suggestions of other lecturers whom the researcher could contact within the college. She was recommended to talk to Christine in the

Mathematics Department but was asked to request the permission of the Head of the Mathematics Department, Ray.

The experience, however, was very valuable to the researcher. She realised the difficulty in conducting a focus interview. As the interview was conducted in a group, it quickly became, instead, an informal and conversational discussion. She could not maintain total control of the situation. However she also realised that having the interview conducted after a meeting could have contributed to the difficulty. The atmosphere, though, was more relaxed and very conducive in generating discussions. She also realised that note-taking was very difficult as she participated in the discussions. She could not write quickly enough to get all the points. She had to resort to jotting down the main points and wrote up the full notes as quickly as possible after the meeting.

After Ray's permission was sought, a meeting and interview was set up with Christine. It took place on the 23rd March, 1990. For this interview, the researcher prepared a list of possible topics and had taken along a tape recorder. During the interview, Christine stated that her students were only doing basic Mathematics. She did not think that they would be taking Engineering degree courses when they had finished with the course. However she also taught first year GCE A level students who had entered with Intermediate GCSE results. We had a discussion on the mathematical background of the students she taught. During the interview, Fielding and George came in. Christine shared the office with them. Fielding taught GCE A level Mathematics and George taught BTEC Mathematics. The researcher was already introduced to George. She met him at a part-time Msc course in Mathematical Education at LUT. She had been attending some of the lectures of the course as well. Fielding and George also participated in the discussions.

They seemed to be unanimous in their opinions that students coming into the college for the various non-GCE A level and the GCE A level courses they taught had 'gaps in their background'. The students were said to be, in general, having basic Mathematics difficulties. Among these were the inability to factorise especially with fractions, they were too dependent on calculators and unable to recognise numbers, prime numbers and multiplication tables. They also had low motivation and lacked the confidence to do their own work. However they agreed that the range of abilities were very mixed and wide. They felt that students who really wanted to do the GCE A level would have remained in school and the ones they had might not even want to go to polytechnics or universities.

The researcher was surprised at the strong and firmly agreed views of the lecturers. They were not confident that their students or any non-traditional qualified students would be able to complete their studies at polytechnics or universities. Christine, in particular said that the students were already stretched to the maximum of their abilities at college. However she felt that as they seemingly could do the work at college, the students felt encouraged to go further but would usually not be able to cope in universities. All three firmly said that the GCE A levels were the best educational background to prepare for a degree education at university.

George taught Mathematics to students on the BTEC Engineering courses. The researcher took the opportunity of setting up a further interview with him. This was to take place on the 26th March, 1990.

Christine, then introduced the researcher to Maurice H, who taught BTEC students. Fortunately, he agreed to be interviewed on such short notice. The interview was conducted in is room but was not recorded on tape. The following accounts were based on notes taken during the interview.

> He has had 25 years experience teaching Mathematics mainly to the vocational students. He thought that his students would mainly go to polytechnics rather than universities and that not all would be taking up degree courses as some would go on to take up HNC/HND. He also felt that the students were weak in Mathematics on entry into college and would usually need help in Algebra and in performing calculator operations. He said that he found it difficult to get them up to a good standard and claimed that this was a recent trend.
>
> He told the researcher that on his own initiative, BTEC Engineering students at LC were already doing more Mathematics than the recommended syllabus as he felt that this would help them cope with higher Mathematics. He also felt that due to the financial constraints placed on colleges, the universities should take the lead in implementing schemes to help such students upon entry to the university. His suggestions were:
> (1) the students problems should be identified and that they should be given extra help, if required;
> (2) modify the contents of the first year course. He gave the example of the Mathematics course in LC, instead of 2 hours for Mathematics, the students were given 3 hours.

During all the interviews with the lecturers, they talked of the constraints on their working conditions and the difficulties of raising funds for schemes to help students. Later it became known, through George, that they were in a middle of a union work-to-rule action to protest about their salaries. They have had no increase for over two years.

George was a most helpful respondent as he had helped the researcher to understand the BTEC courses. She also had the opportunity to see him every Wednesday afternoons, when he would be at LUT, as he was following a part-time Msc course in Mathematical Education. Thus, some informal discussions were conducted during some of these occasions. George was interviewed twice, once on the 26/3/90 and again on the 11/10/90.

During the first interview, the conversation revolved around the BTEC courses he was teaching, some of his work related problems and his own background. He was an Engineer before he came into teaching. He described briefly how courses were moderated by BTEC. He claimed that one of the problems with the BTEC courses was that the syllabus was broken down into separate units and that each unit was tested as a complete unit. He said that this made it difficult to teach the course in an integrated manner.

He also expressed opinions similar to his colleagues when he was discussing his students. He felt that generally the student were lacking in confidence and had some gaps in their mathematical background. In particular, he said that students who had entered the BTEC courses with grades C on the Intermediate level would have done less Algebra, Trigonometry and Geometry compared to those who had GCSE grades on the Higher level. During the first interview, George told the researcher that the staff at LC were having problems related to working hours and their salaries. Some time was spent on this issue in the interview. Christine too had mentioned similar problems.

In the second interview with George, he described further some aspects of teaching BTEC Mathematics and that some changes were made to the syllabus, In fact, he was teaching from the old and new syllabus at the same time as he had different groups of students on each. Even though the information received from George were patchy, they helped to clarify to the researcher some aspects and problems related to the implementation of the BTEC courses at LC.

2. MB

The researcher also had an opportunity to visit another college, MB in Birmingham. The visit was actually to an Mathematics Open Learning Centre that catered for students on BTEC and ACCESS courses. Similar to LC, it was disclosed that the students on ACCESS course here were usually preparing for non-Science based courses at university or polytechnics. However, an interview was conducted with a Mathematics lecturer, Maurice, teaching BTEC Mathematics who was a volunteer staff at the OL centre. The interview took place on the 2nd May, 1990.

Maurice gave the researcher some general information on the BTEC courses conducted in the Engineering department and on the BTEC Mathematics course. He emphasised that at MB, the Mathematics taught were practical Mathematics, in that the students were taught Mathematics and its uses in practical situations. He claimed that in his department, it was the Engineers who taught Mathematics and that there were no Pure Mathematics teacher.

In his account, he talked of some students difficulties that he was familiar with. He said that with day-release students, they usually were from the same company and they would form 'cliques' though discipline was not a problem. Their learning problems centred on their weakness in basic mathematical calculations, having problems in Algebra and Indices. He thought that these problems were probably from the schools. In MB, extra help were given to the students in the Open Learning Centre. He claimed that during the three year course, there had been great improvements in the students mathematical abilities which he linked to changes their in attitudes as they became more mature.

In the months of April and June, several interviews were conducted with staff at LUT which would be reported in the appropriate sections. From an UCCA guidebook (UCCA, 1990) to University Selectors, the BTEC qualifications were designated as F, N and H levels which were then matched to the older designations of levels I-

V. The new designations were supposedly introduced since 1985. During interviews with the staff at LC, MB, LUT and, a few students, the BTEC qualifications were all referred to by the older levels of I-V. This prompted the second interview with George, in order to know how the qualifications were actually designated. George admitted that the designations have changed but they were allowed to present the current qualifications in the older designation as well. This was hoped to be an interim measure until the current designations became more familiar.

Discussion

The interviews conducted with the staff at the colleges were helpful to the researcher in several ways. Firstly, they helped the researcher to find out from the teachers involved in the implementation of the BTEC courses, what were the problems they faced. Information on BTEC were supplemented by further readings on relevant BTEC publications. Secondly, they were among the first interviews that were conducted and they helped her to polish her interviewing techniques and made her aware of some of the technical difficulties of recording the interview.

Information from the interviews, however, implied that students on BTEC courses at these colleges, were already weak in mathematics upon entry and that the BTEC Mathematics courses did not allow much time for these students to practise on the topics required. At least teachers at LC thought that the students needed an extra unit in Mathematics if they were to cope with Mathematics in courses at degree levels.

In both LC and MB, there were no ACCESS student who would be going into an Engineering degree course. Their ACCESS students were going into other courses such as Education, and science-based courses. Both the colleges did not have Foundation courses for students who would like to take up degree courses.

From the beginning of the research, the researcher was aware that the students coming into the degree courses with BTEC qualifications were considered having had a weaker Mathematics background. The explanations given to her by members of staff at LUT were that these BTEC students did not have enough time on Mathematics in the BTEC courses. The information gathered from the teachers at LC and MB were based on their past experiences with BTEC students and some were only relevant to the current students. However these opinions indicated the possibility that the students had a weak Mathematics background even before doing the BTEC courses.

Appendix 3

LUT Entry Requirements for the School of Engineering (reproduced from the Undergraduate Prospectus, October 1991 entry).

Civil Engineering

1. Civil Engineering
(Three and four year courses)

You will need 18 points from two or more A levels. Of these, one must be a Mathematics subject in which you have obtained at least a Grade C. In Physics the minimum requirement is a Grade C at GCSE. General Studies is not acceptable as one of the offered A levels but will be taken into account if you have not gained the full 18 points and special entrance concession is being considered. Two AS levels will be accepted as a third A level.

BTech qualifications will be considered on an individual basis, but you will normally be required to offer an 85%+ passmark at Mathematics Level III, as well as an average passmark of 75% from three other Level III subjects.

Qualifications other than the ones mentioned - including those from overseas - will be considered on individual merit.

2. Civil and Building Engineering
(Four or five year course)

These are identical to those of the BEng Honours in Civil Engineering. In addition your work during the first three years must be of a sufficiently high standard to allow you to enter the final year.

3. Civil Engineering and German
(Four year sandwich course)

You will need 18 points from two or three A levels plus at least a Grade B in GCSE German. One of the A levels must be a Mathematics subject with a minimum grade C. You must also have at least a Grade C in GCSE Physics. General Studies is not accepted as one of the offered A levels, but if you do take it the results will be taken into account if you do not obtain 18 points and a concession is being considered. One of the A levels may be replaced by two AS levels.

Many other qualifications are considered individually including BTEC and those from overseas.

4. Building Services Engineering
(Three or four year sandwich course)

You will need 18 points from two or three A levels, one must be a mathematical subject in which you have obtained at least a Grade C. You will also need Physics with at least a Grade C at GCSE. General Studies is not acceptable as one of the offered A levels, but if you

do obtain it the grade will be taken into consideration if you do not obtain the 18 points and a concession is being considered.

Two AS levels will be accepted as one a level. BTEC qualifications are considered individually but as a guide the level will be about 85% Level III Mathematics plus 75% average from three other Level III subjects.

5. Construction Engineering Management
(Four year sandwich course)

You will need 20 points from any three approved A levels. The minimum requirement in Mathematics and Physics is a Grade C at GCSE. One of the A levels may be replaced by two AS levels.

Those of you with other qualifications, such as BTEC, who are mature applicants will be considered individually. In addition to the academic requirements you must be sponsored by one of the firms sponsoring the course. A list of these firms is available from the Department.

Electronic and Electrical Engineering

1. Electronic and Electrical Engineering
(Three, four and five year courses)

2. Electronic, Computer and Systems Engineering
(Three and four year courses)

3. Electro-Mechanical Power Engineering
(Three and four year courses)

A level applicants will normally need to have three passes including at least one in a Mathematics subject and one in Physics or Engineering Science. Passes in two subjects at AS level are acceptable in lieu of a third A level. It is emphasised that the third A level subject does not need to be either scientific or technical but General Studies is not acceptable.

If you offer BTEC qualifications you will be considered individually but you should note that a good performance in Mathematics is usually necessary.

Manufacturing Engineering

1. Manufacturing Engineering and Management

2. Electronics and Manufacturing Engineering

Normally you will need to have 3 A level subjects at Grade C, which must include Mathematics and either Physics or Engineering Science or Nuffield Physical Sciences.

If you offer Scottish Certificate of Education qualifications they must include Mathematics and Physics and one other Science or Technology subject at the Higher level or CSYS level.

The department welcomes applications from candidates taking BTEC qualifications. Normally 4 level III subjects are required with an overall average of 75%, with 80% in Mathematics. Applicants who have taken higher levels at BTEC will be considered individually.

3. Design and Manufacturing Engineering

Normally you will need three A level subjects at Grade C which must include Mathematics and one other approved Science subject.

If you offer Scottish Certificate of Education qualifications, they must include Mathematics and Physics and one other Science or Technology subject at the Higher level or CSYS level.

The department welcomes applications from candidates taking BTEC qualifications. Normally 4 level III subjects are required with an overall average 75%, with 80% in Mathematics. Applicants who have taken higher levels at BTEC will be considered individually.

Mechanical Engineering

1. Mechanical Engineering

2. Mechanical and Materials Engineering

If you come to Loughborough to read Mechanical Engineering you will need to have A levels in Mathematics, Physics (or Engineering Science [JMB] or Physical Science) and a third A level or two AS levels. The minimum standard required is at least 20 points, with, at present, a requirement for a C grade in both Mathematics and Physics (or its equivalent), but this may vary from time to time. Variations on these standards will take account of GCSE/O level subjects and whether you are attempting A level subjects for a second time. English language at GCSE/O level is also a requirement.

If you are offering a BTEC qualification, an average of 75% overall and at least 80% in Mathematics at Level III or Diploma standard will be expected, and HNC/HND candidates with this sort of Level III or diploma performance will be required to obtain merits in all subjects.

APPENDIX 4: QUESTIONNAIRES

4(1) CIVIL ENGINEERING DEPARTMENT'S

4(2) RESEARCHER'S

4(3) MATHEMATICAL SCIENCES DEPARTMENT'S

Summary of 7 forms

DEPARTMENT OF CIVIL ENGINEERING

The purpose of this questionnaire is to allow students to comment on a group of lectures (or other teaching periods) all taken by one member staff. Normally a questionnaire should be issued in the last lecture in a sequence of five to ten on a well defined part of the syllabus. These headings should be filled in by the lecturer before copying and distributing the questionnaire.

Subject.....MATHS (BTEC.....Lecturer.....

Date when questionnaire distributed.....9 Nov 1990.....

Referring to.....15 + 5 Tutorials.....(number) lectures each.....1.....hour(s)

in the period (dates).....Oct 7.....to.....Nov 9.....

Students should consider each question separately and tick the box which best fits their reaction. Any particularly good or bad points should be explained in comments at the bottom of the page. Students should not put their name on questionnaires The lecturer should collect the questionnaires immediately after the lecture in which they are distributed and pass them to the Subject Leader.

	excellent	good	fair	bad	
1. **Organisation** - Did the lectures start and finish on time as expected?	1	6			
2. **Material** - Did each lecture cover a well defined topic in an orderly manner?		2	5		
3. **Clarity** - Was the presentation of each lecture clear and easy to understand?		1	2	4	
4. **Visual Aids** - Were blackboard, ohp and/or slides used well?		2	5		
5. **Handouts** - Were useful handouts given which helped in understanding?		4	3		
6. **Tutorial Assistance** - were examples given and was help available?		5	2		
7. **Rapport** - Was the lecturer helpful in answering questions?		5	1		1 didn't answer this

	far too much	too much	about right	too little	far too little
8. **Quantity** - Was the amount of material in each lecture about right?		4	2	1	
	far too difficult	**too difficult**	**about right**	**too easy**	**far too easy**
9. **Level** - Was the lecture at a level which was interesting and challenging		5	2		

Comments Two comments from seperate forms :

1. Not enough basic examples
2. Although I said class was fast, Mathematics is not easy to teach, and not many lecturers would get more than fair
3.

From: Roselainy Abdul Rahman
Mathematical Sciences Department
Loughborough University of Technology

Date: 31st January 1991.

Dear Student

Research Questionnaire

I am carrying out a research to study mathematics provision for students on undergraduate Engineering courses who have entered with BTEC qualifications. I hope the research will help future developments of such courses.

As part of my research programme, I should like to gather further details of your course, entry qualifications and work experience. This information would help my research greatly, as well as supporting other data collected through my observations and interviews.

I should be most grateful for your assistance in my work. Everything you decide to tell me will be treated in strict confidence and any resulting research report will preserve your anonymity.

Thank you for your help.

Yours sincerely

RAR/

Roselainy Abdul Rahman.

RESEARCH QUESTIONNAIRE

First Year Mathematics Course

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1 About yourself:

Please fill in boxes,

Name: ☐

Age: ☐ Years

---

2 About your undergraduate course:

(i) Which department are you in ?
Please tick box.

Civil Engineering ☐

Electronic and Electrical Engineering ☐

Manufacturing Engineering ☐

Mechanical Engineering ☐

Transport Technology ☐

(ii) Which undergraduate course are you following ? please tick box.

Civil Engineering

Civil Engineering	BEng (Honours) Three-year course UCCA Code: H200	☐
	BEng (Honours) DIS Four-year course UCCA Code: H201	☐
Civil Engineering and Building	MEng (Honours) Four-year course UCCA Code: H2K2	☐
	MEng (Honours) DIS Five-year course UCCA Code: H2KF	☐
Building Services Engineering	BEng (Honours) Three-year course UCCA Code: K240	☐
	BEng (Honours) DIS Four-year course UCCA Code: K241	☐
Civil Engineering and German	BEng (Honours) Four-year course UCCA Code: H2R2	☐
Construction Engineering Management	BSc (Honours) Four-year course UCCA Code: H291	☐
Commercial Management and Quantity Surveying	BSc (Honours) Four-year course UCCA Code: HK22	☐

Mechanical Engineering

Mechanical Engineering	BEng (Honours) DIS Four-year course UCCA Code: H301 Mech Eng 4	☐
	MEng (Honours) DIS Five-year course UCCA Code: H301 Mech Eng 4	☐
	BEng (Honours) Three-year course UCCA Code: H300 Mech Eng 3	☐
	MEng (Honours) Four-year course UCCA Code: H300 Mech Eng 3	☐
Mechanical and Materials Engineering	BEng (Honours) DIS Four-year course UCCA Code: HJ3M Mech/Matls 4	☐
	BEng (Honours) Three-year course UCCA Code: HJ35 Mech/Matls 3	☐
Engineering Science and Technology	BEng (Honours) DIS Four-year course UCCA Code: H101 Eng Sci 4	☐
	BEng (Honours) Three-year course UCCA Code: H100 Eng Sci 3	☐

Note:

Electro-Mechanical Power Engineering

This course is run in collaboration with the Department of Electronic and Electrical Engineering.

Please tick box under Electrical & Electronic Engineering

Electronic & Electrical Engineering

Electronic and Electrical Engineering	BEng (Honours) DIS Four-year course UCCA Code: HH65 Elect Eng 4	☐
	BEng (Honours) Three-year course UCCA Code: HH56 Elect Eng 3	☐
	MEng (Honours) DIS Five-year course UCCA Code: HH6M Elect Eng	☐
	MEng (Honours) Four-year course UCCA Code: HH5P Elect Eng	☐
Electronic, Computer and Systems Engineering	BSc (Honours) DIS Four-year course UCCA Code: H611 Syst Eng 4	☐
	BSc (Honours) Three-year course UCCA Code: H610 Syst Eng 3	☐
Electro-Mechanical Power Engineering This course is run in collaboration with the Department of Mechanical Engineering	BEng (Honours) DIS Four-year course UCCA Code: HH63 ElMech Power 4	☐
	BEng (Honours) Three-year course UCCA Code: HH36 ElMech Power 3	☐
Electronic Engineering and Physics	BSc (Honours) DIS Four-year course UCCA Code: HF63 Elec/Phys 4	☐

Note:

Electronics and Manufacturing Engineering This course is run by the Department of Manufacturing Engineering.	Please tick box under Manufacturing Engineering

Manufacturing Engineering

Manufacturing Engineering and Management	MEng (Honours) DIS Five-year course UCCA Code: H783 Man/Eng	☐
	MEng (Honours) Four-year course UCCA Code: H783 Man/Eng	☐
	BEng (Honours) DIS Four-year course UCCA Code: H781 Manuf/Man 4	☐
	BEng (Honours) Three-year course UCCA Code: H780 Manuf/Man 3	☐
Design and Manufacturing Engineering	BEng (Honours) DIS Four-year course UCCA Code: H771 Des/Manuf 4	☐
	BEng (Honours) Three-year course UCCA Code: H770 Des/Manuf 3	☐
Electronics and Manufacturing Engineering	BEng (Honours) DIS Four-year course UCCA Code: HH76 Elec/Manuf 4	☐
	BEng (Honours) Three-year course UCCA Code: HH67 Elec/Manuf 3	☐

Transport Technology

Aeronautical Engineering	BEng (Honours) DIS Four-year course UCCA Code: H401 Aero Eng 4	☐
	BEng (Honours) Three-year course UCCA Code: H400 Aero Eng 3	☐
Automotive Engineering	BEng (Honours) DIS Four-year course UCCA Code: H341 Auto Eng 4	☐
	BEng (Honours) Three-year course UCCA Code: H340 Auto Eng 3	☐
Transport Management and Planning	BSc (Honours) DIS Four-year course UCCA Code: N921 Trans/Man 4	☐
	BSc (Honours) Three-year course UCCA Code: N920 Trans/Man 3	☐

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3 About your education background:

(i) Which was your **main** entrance qualification to the undergraduate course above? Please tick box.

- BTEC National Certificate ☐
- BTEC National Diploma ☐
- BTEC Higher National Certificate ☐
- BTEC Higher National Diploma ☐
- Other ☐

(ii) How did you study for your main entrance qualification?
Please tick boxes.

- Full-time ☐
- Part-time – Day release ☐
- Part-time – evenings only ☐
- Block Release ☐
- Distance Learning ☐
- Open Learning ☐

(iii) Please list all your BTEC Mathematics qualifications.

Unit Title and code	Unit value	Level	Pass Merit Distinction	Where obtained (name of educational institution)	Date

(iv) Please list any other mathematics qualifications that you have e.g. GCSE, GCE 'A' Levels, International Baccalaureate etc.

Qualifications	Grades	Where obtained (name of educational institution)	Date

4 About your work experience:

Please list your working experience, if any.

Name of Employer	Nature of Work (briefly)	Dates

5 About your sponsors:

(i) Are you sponsored ?
Please tick box.

Yes ☐

No ☐

(ii) If yes, please state the name of your sponsor

LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY

Department of Mathematical Sciences

Evaluation Questionnaire: Student Feedback

End of Module

In order to develop and improve this module and the overall course in succeeding years, your assistance in completing this questionnaire would be greatly appreciated. If you wish to remain anonymous, your wishes will be respected entirely. Your responses will be taken into account whether or not you put your name on this questionnaire. It would, of course, be helpful if you would indicate your course and the module concerned.

Name

Degree Course

Module

The following statements refer to aspects of the module.

Please read each of the statements carefully, before putting one tick in the box which best shows your feeling.

		I strongly agree	I agree	I am not really sure	I disagree	I strongly disagree
1	This module is a valuable part of the overall course	☐	☐	☐	☐	☐
2	The subject content of the module was appropriate for me	☐	☐	☐	☐	☐
3	The academic level of the module was appropriate for me	☐	☐	☐	☐	☐
4	The pace of the module suited me	☐	☐	☐	☐	☐
5	The module helped me to learn many mathematical facts	☐	☐	☐	☐	☐
6	The module helped me to develop many mathematical techniques and skills	☐	☐	☐	☐	☐
7	The module helped me to see ideas and concepts clearly	☐	☐	☐	☐	☐
8	The module has increased my confidence in mathematics	☐	☐	☐	☐	☐
9	The module has helped me to appreciate the nature of mathematics	☐	☐	☐	☐	☐
10	I found the subject matter of the module interesting	☐	☐	☐	☐	☐

	I strongly agree	I agree	I am not really sure	I disagree	I strongly disagree
11 I found the subject matter of the module exciting	❑	❑	❑	❑	❑
12 The lecturer was enthusiastic about the subject	❑	❑	❑	❑	❑
13 The lecturer engendered enthusiasm for the subject	❑	❑	❑	❑	❑
14 The lecturer was responsive to students' needs	❑	❑	❑	❑	❑
15 The lecturer respected students ideas and opinions	❑	❑	❑	❑	❑
16 The overall teaching strategy and style were appropriate for this module	❑	❑	❑	❑	❑
17 The techniques of teaching were good	❑	❑	❑	❑	❑
18 The module was well organised	❑	❑	❑	❑	❑
19 The integration of lectures, tutorials, workshops, lab-work etc. worked well	❑	❑	❑	❑	❑
20 The recommended texts and reading lists were useful and appropriate	❑	❑	❑	❑	❑

If you have any further comments, which may help in developing the module and the course in general please make them below. In particular, if you have strongly agreed or strongly disagreed with any of the statements above, please feel free to amplify your views and opinions below.

Comments relevant to teaching and learning aspects of the module

Comments on the design, organisation and implementation of the module

Other General Comments

APPENDIX 5

Researcher's attendance record
P: Present A: Absent

WEEK	DATES	LECTURES	PROB CLASS	TUTORIAL	COMMENTS
AUTUMN TERM					
1	2/10/90	1:Introduction 2:Complex nos.			
	5/10/90		P		
2	9/10/90	1:Vectors 2:Vectors			
	10/10/90			ME/EMPE	
	11/10/90			EL/ECS	
	12/10/90	3:Vectors		CIV	
3	16/10/90	1:Inequalities/ Partial Fractions 2:contd			15/10: Interviews
	17/10/90			ME/EMPE	
	18/10/90			DME/EME & EL/ECS	
	19/10/90	3:Review & indiv help			
4	22/10			MME	
	23/10	1:Conics 2:Computer Lab			
	24/10	did			look thro'
	25/10	not			notes
	26/10	attend			
5	30/10	1:Functions 2:Functions			
	31/10			ME/EMPE	
	1/11			DME/EME	
	2/11	3:Computer Lab			
6	5/11			-	week off Manuf & Elec
	6/11	1: P 2:Lab session			
	9/11	3: P		CIV	
7	12/11			MME	
	13/11	1: P 2: A			
	14/11			ME/EMPE	
	15/11			DME/EME,EL/ECS	
	16/11	did not attend			
8	19/11 - 23/11	did not attend			
9	27/11	1: P 2: Lab. session			

WEEK	DATES	LECTURES	PROB CLASS	TUTORIAL	COMMENTS
9	28/11			ME/EMPE	
	29/11			DME/EME,EL/ECS	
	30/11	A			
10	3/12			MME	
	4/12	1: P			
		2: P			
	5/12			ME/EMPE	
	6/12			did not attend	
	7/12	P		CIV	
SPRING TERM					
11	8/1/91	1: P			Manuf.- Eng App; Elect-exams
	9/1-12/1	did not attend			
12	15/1	1: P	2: P		
	16/1			A	could not find class
	17/1			EL	
	18/1	P		CIV	
13	21/1			MEM	
	22/1	A			
	23/1			MECH	
	24/1			DME/EME	
	25/1	A			
14	28/1-1/2/91	did not attend			look through notes
15	4/2			MEM	
	5/2	1:P	2:P		
	6/2			MECH	
	7/2			DME/EME.EL,EMPE	
	8/2	A			
16	11/2			MEM	
	12/2	1:P			
	13/2			MECH	
	14/2	No Tutorial			
	15/2	P		CIV	
17	18/2			MEM	
	19/2	1:P, 2:P			
	20/2-22/2	did not attend			
18	25/2			MEM	
	26/2	1:P, 2:P			
	27/2			MECH	
	28/2			EL.DME/EME, EMPE	
	1/3	P		CIV	

WEEK	DATES	LECTURES	PROB TUTORIAL CLASS	COMMENTS
19	4/3		MEM	
	5/3	1:P, 2:P		
	6/3			
	7/3		DME/EME	
	8/3	P		
20	11/3		MEM	
	12/3	1:P, 2:P		
	13/3			
	14/3		DME/EME.EL	
	15/3	P		
SUMMER TERM				
21	29/4			Manuf Eng: Engineering Applications
	30/4	1:P, 2:P		Civils only
	1/5			
	2/5		MECH	MECH has only 2 hours
	3/5	P:Revision		MECH/CIV
22	6/5	MAY DAY HOLIDAY		
	7/5	1:P, 2:P		
	9/5		DME/EME,MECH	
	10/5	P:Revision		
23	13/5		MEM	
	14/5	1:P, 2:P		
	16/5		DME/EME, MECH	Special Session for DME:1 came.
	17/5	P	CIV	
24	20/5		MEM	
	21/5	1:P, 2:P		
	23/5			nobody came for tutorial
	24/5	P		
25	27/5	HOLIDAY		
	28/5	A		
	30/5	No Tutorial		
	31/5	P	CIV	

MC1/CV1/EL1/MU1 1990 - 1991

Mathematics Programme

Term 1

Week 1 Complex numbers

Week 2 Vectors

Week 3 Algebra: Inequalities, moduli, partial fractions
Determinants and matrices

Week 4 Coordinate systems and standard equations of Conics

Weeks 5 - 7
FUNCTIONS

Weeks 8 - 10
DIFFERENTIATION

Term 2

Weeks 1 - 4
INTEGRATION

Weeks 5 - 6
PARTIAL DIFFERENTIATION

Weeks 7-10
SOLVING EQUATIONS
(a) Numerical methods for non-linear equations
(b) Systems of equations

Term 3

Weeks 1 - 4
ORDINARY DIFFERENTIAL EQUATIONS

Week 5 Difference Tables:
Interpolation and Numerical differentiation

Course Text:

K A Stroud	*Engineering Mathematics* Programmes and Problems	3rd Edition Macmillan

MC1/CV1/EL1/MU1 1990 - 1991

Mathematics Programme
(Revised)

Term 2

Weeks 1 - 3
INTEGRATION

[Some activities, tests and exams take place in Electrial and Manufacturing departments during week 1]

Note:
There will be a Maths Test in week 3 on Tues 22 Jan at 9.00 a.m. in Room R005

Weeks 4 - 5
PARTIAL DIFFERENTIATION

Weeks 6 - 7
SOLVING EQUATIONS
(a) Systems of equations
(b) Numerical methods for non-linear equations

Weeks 8 - 10
ORDINARY DIFFERENTIAL EQUATIONS

Term 3

Students from the Electrical Engineering Department will work with the "A-level" group in that department (the lecturer is Mr. G. Simpson) to cover the syllabus on *Vector Analysis.*

Students from the Manufacturing, Mechanical and Civil Engineering Departments will continue as a "BTEC Group". This group will do an introductory course to *Statistics.*

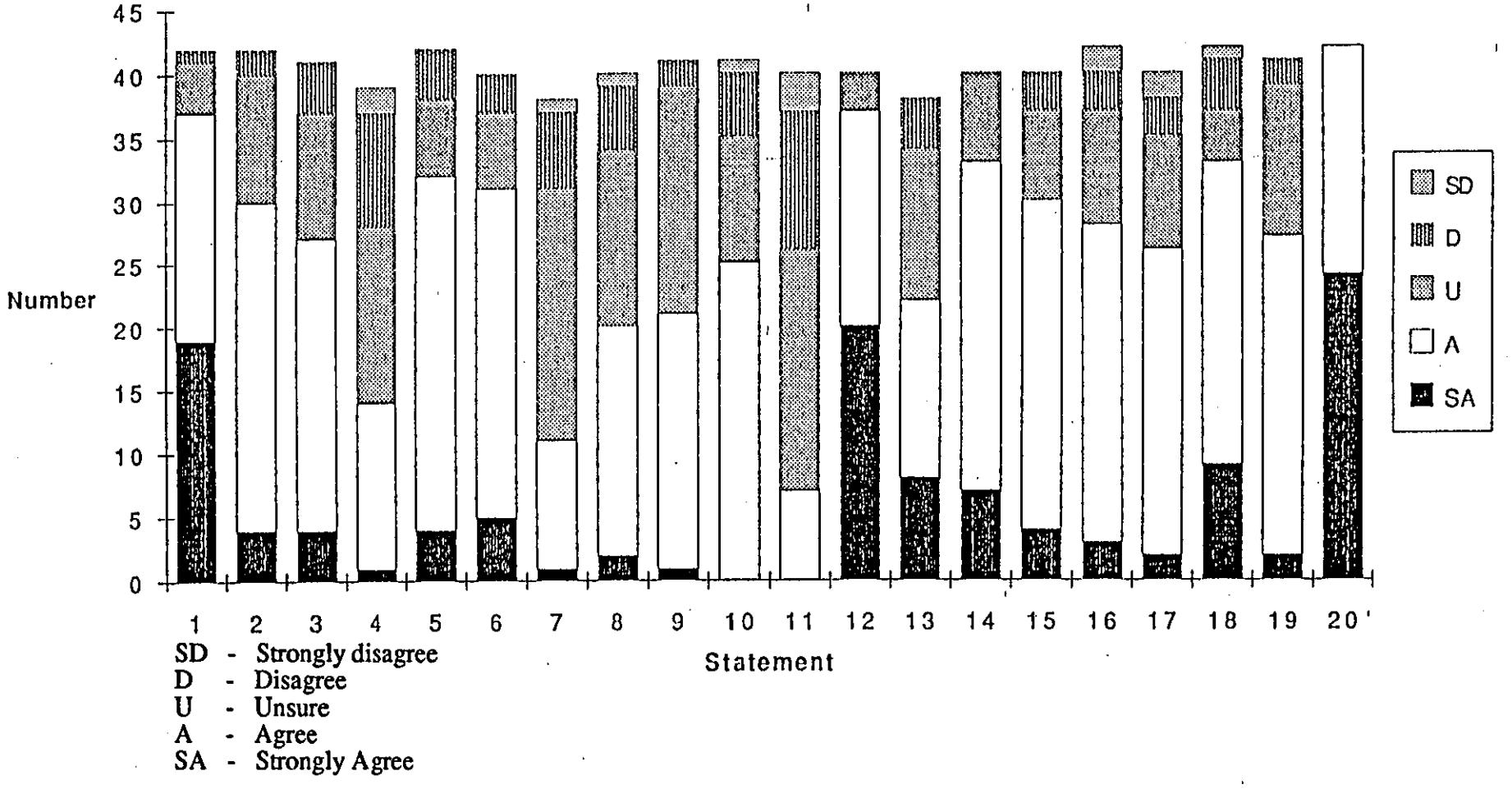
Course Text:

K A Stroud	*Engineering Mathematics* Programmes and Problems	3rd Edition Macmillan

Appendix 7: Students Interview list and dates

		DATES(TERM,WEEK)	
	NAME	First interview	Second intvw
1.	Cy	9/10/90 (1,2)	12/2/91 (2,6)
2.	Ben	12/10/90 (1,2)	13/3/91 (2,10)
3.	Ramu	12/10/90 (1,2)	
4.	Andy2	15/10/90 (1,3)	
5.	Steve2	15/10/90 (1,3)	
6.	Bob	16/10/90 (1,3)	
7.	Rick1	16/10/90	
8.	Naza	16/10/90	
9.	Jill	17/10/90 (1,3)	14/3/91 (2.10)
10.	Ari	18/10/90 (1,3)	20/3/91 (2,hol)
11.	Chan	22/10/90 (1,4)	
12.	Dave2	23/10/90 (1,4)	
13.	Nick	24/10/90 (1,4)	
14.	Billy	24/10/90 (1,4)	20/2/91 (2,7)
15.	Des & Alex	26/10/90 (1,4)	
16.	Dan2	30/10/90 (1,5)	4/2/91 (2.5)
17.	Stuart2	4/2/91 (2,5)	
18.	Paul	1/11/90 (1,5)	
19.	Dan1	1/11/90 (1.5)	1/3/91 (2.8)
20.	Hugh, Stuart1		
	& Dave1	1/11/90 (1,5)	
21.	Steve1	2/11/90 (1,5)	11/3/91 (2,10)
22.	Matt2		11/2/91 (2,6)
23.	Tom1	Feb. (2,-)	
24.	Rick2	11/3/91(2,10)	
25.	Tom2 & Les	16/5/91(3.3)	

OVERALL STACKED CHART



SD - Strongly disagree
D - Disagree
U - Unsure
A - Agree
SA - Strongly Agree

Appendix 9

Rational models of curriculum development

Taylor and Richards (1986) discuss three principal models developed based on the rational theory of curriculum development, which are:

(1) The Objectives Model and its variants (Tyler, 1949; Taba, 1962)

The development of this model was strongly influenced by behavioural psychology. In general, the model consisted of four major components [Figure (i)]. The first and essential stage in this model is the determination of the 'objectives' of the curriculum. These are statements of goals which should describe or illustrate the kind of behaviour the students were to perform as well as the areas of content in which that behaviour was to be applied. It is an important feature of this design model that the objectives are specified first before the other components are considered. There have been various attempts to improve the model (Taba, 1962; Goodlad & Richter, 1966; Wheeler, 1967). However the stress of these newer models are still on the specific, measurable objectives at classroom level.

There have been considerable criticisms directed at the objectives models. The main criticisms have been concerned with the determination and clarifying of objectives, especially behavioural objectives. The objections to the use of objectives have been based on philosophical considerations, specific discipline considerations and practical considerations. It is difficult to translate into clear observable behaviours certain important outcomes of education such as understanding, appreciation and knowledge. Some critics challenged the ability of the models to reflect the actual processes of the planning situations. The objective, rational models suggested that the developers worked in an ordered manner and progressed through the different stages linearly. These were not reflected in practice as issues that affect one stage would sometimes simultaneously affect the other stages. The models also presupposed that the ends of the learning experiences could be fixed at an early stage of the development. This was not usually apparent when actual working processes were observed.

(2) The Process Model (Stenhouse, 1975);

The process model was not developed to be all-embracing and did not reject totally the objectives model though it came about as an alternative to the objectives model. It was developed by Stenhouse and he suggested that this model would be more appropriate in areas of curriculum which stresses on understanding and knowledge. He argued that the objectives model was more suitable in areas which emphasised information and skills (Stenhouse, 1975). In this model, the emphasis was on specifying the contents to be studied, the principles of procedure, and the teaching methods to be used rather than objectives to be achieved.

The model has not been subjected to much criticism though certain weakness have been identified. Among these were the difficulty in assessing students' work and that its success relied heavily on the quality of the teacher. Stenhouse acknowledged that, '*it is far more*

demanding on teachers and thus far more difficult to implement in practice, but it offers a higher degree of personal and professional development.' (Stenhouse, 1975)

(3) The Situational Model (Skilbeck, 1976; Lawton, 1983)

This model [Figure (ii)] stressed the importance of curriculum design and development to be placed within a cultural framework. Thus the planning of the curriculum should be made with an appreciation and considering of the school situation. The model has five major components:

(1) Situation analysis
(2) Goal formulation
(3) Programme building
(4) Interpretation and implementation
(5) Monitoring, assessment, feedback and construction.

This model did not require a linear progression through its components. Planners could start at any stage taking into account the different elements of the curriculum development process.

FIGURE (I)

Ralph W. Tyler (1949)

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?

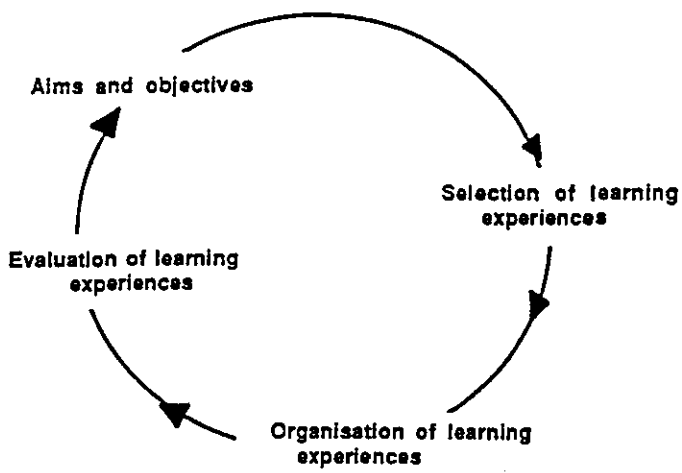


FIGURE (II)

The 'Situational' Model: Malcolm Skilbeck, 1982