EDUCATING AND TRAINING MATHEMATICS TEACHERS FOR SECONDARY SCHOOLS IN IRELAND : A NEW PERSPECTIVE ON TEACHER EDUCATION

By

JOHN O'DONOGHUE BS MS

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of the Loughborough University of Technology, November 1978.

Supervisor: Professor A.C. Bajpai, Director of CAMET and Head of the Department of Engineering Mathematics

ACKNOWLEDGEMENTS

The author has received encouragement and assistance from various sources during the course of this research project. It is his pleasant duty now to acknowledge a debt of gratitude and extend sincere thanks to all those who helped in any way but especially to the following persons and bodies.

Professor A C Bajpai, Director of CAMET and project supervisor, deserves special mention for his contagious zeal in professing mathematics wherever he goes but especially in Ireland. As research supervisor he has been a constant source of assistance, guidance and motivation, and at the same time enormously generous and kind.

My colleagues Mr J Logan and Mr T V Power have been a constant source of help and support, morally and materially - Mr Power in bringing the semantic differential to my attention and giving kind permission to use his validated form, and Mr Logan by making available his not inconsiderable book collection on Irish education.

It is with pleasure that the author acknowledges the financial and administrative assistance provided by the Governing Body of Thomond College. The project could not have been completed without the support of Dr J N Oliver (past Director) and the active continuing support of Mr J Christian, Director of Thomond College.

Thanks are also due the library staff at the National Institute for

Higher Education, Limerick especially Mrs B Frawley.

The author is grateful to the Irish Department of Education and the Inspectorate, under whose aegis the computer education courses were initially held enabling the author to make contact with Professor Bajpai and CAMET for the start of this research work.

Acknowledgement is also due to the National Council for Educational Awards and in particular to the Director, Mr P MacDiarmada for providing the opportunities for the field work.

This manuscript was typed by Mrs B Clancy whose diligent and painstaking efforts merit special praise.

Finally, my wife Deirdre, deserves special mention for her much appreciated patience and moral support without which the project might never have been completed.

LIST OF CONTENTS

Chapter

CHAPTER I

AIM AND SCOPE OF THE RESEARCH PROJECT

This thesis is a record of experiments in the education of mathematics teachers for Irish Secondary[1] schools conducted at Thomond College of Education, Limerick during the years 1975-77 inclusive. But it is more than a mere record of successes and failures. In its analyses and syntheses, based on experiments and programmes conducted under actual conditions, it endeavours in a true spirit of research in mathematical education to provide new insights. The research culminates in the redefinition of an old problem in mathematical education, and a first step towards a viable solution to the redefined problem is presented.

The project itself is testimony to an opportunity seized, an opportunity that is, to make a contribution to mathematical education in Ireland. The opportunity arose in the context of the National College for Physical Education, a new-type third level institution in Irish education, later subsumed in Thomond College of Education, a training college for specialist teachers of Physical Education, Metalwork, Woodwork, Rural Science and engineering subjects for Irish secondary schools. The model of teacher education adopted in the college at the outset was a concurrent and integrative four-year degree programme leading to teaching competency in *two* areas of the school curriculum viz. Physical Education and one other area chosen from a list of options which included mathematics. The

---

1. 'Secondary' as used here includes all post-primary schools i.e. private secondary, vocational, comprehensive and community schools. see Chapter III for a full discussion of terms etc in use in Ireland.

author assumed responsibility for mathematics upon his appointment in December 1974 and was the first person appointed in that capacity. Since the whole degree programme was a new one in the Irish context, the author resolved to be innovative in his approach to the mathematical education of student-teachers at the College. Whether by design, omission or confusion - the reason is really academic at this point - the author was afforded a great deal of latitude and personal autonomy, a state of affairs which facilitated the development of new-type programmes. A new programme was devised and implemented in 1975 - *the first of its kind in Ireland* - and later revised and modified. It is hoped that this individual effort has in some small measure shown what is possible and even desirable. It is a complete break with the traditional approach to the training of mathematics teachers which is university-dominated in Ireland and as such might be viewed in retrospect as a small breakthrough.

The focus of the research project is mathematical education, specifically the initial preparation in mathematics of future mathematics teachers for Irish secondary schools. Naturally the education of future mathematics teachers encompasses more than mathematics, and might be more appropriately described as studies in *mathematical education.* However, because the author attaches special significance to the intending teacher's education in mathematics, *the scope of the project is deliberately restricted to that aspect of his preparation although not exclusively.*

Why research the teaching of mathematics to student-teachers who are looking forward to a career as secondary school mathematics teachers? The simple answer is to *improve* that teaching. However, the simple answer can be elaborated in a broader context. Research on teaching is genrally motivated by a variety of considerations but the approaches to such research may be conveniently grouped into two categories: (1) teaching is an *existing* phenomenon and is therefore worthy of study; (2) teaching needs to be improved. Gage and Unruh [1](p.359) described the cleavage in the approaches as follows:

> The first of these approaches regards teaching as a realm of phenomenon worth studying simply because it exists and is fascinating. The second deals with teaching as something needing to be improved, because it is not as good as it ought to be. The first approach resembles that of the anthropologist studying cultures neutrally; *the second, that of the inventor working on a better way to meet a practical need.*
>
> [my italics]

By implication, researchers in the second category take an active approach to the problem and direct their efforts towards developing new models of instruction which when suitably corrected and refined will optimize learning. This is precisely the approach adopted in this thesis to the mathematics education of future mathematics teachers. The author is, therefore, squarely in the camp of the 'improvers'.

Such a stance leads to a consideration of why and in what ways teaching - in this case mathematics teaching - is in need of improvement. *The central issue here is the teaching of teachers of secondary school mathematics in Ireland, and ways and means of improving that teaching.* However, and perhaps more importantly, a dominoe effect is anticipated. If the mathematics education of future mathematics teachers can be improved, then *better* mathematics teachers will take over the mathematics teaching at secondary level and pupils will benefit from an improved mathematics education which in turn will benefit society at large. Ultimately teacher educators must be concerned with improving education in the schools. Arguably, the best way to improve the education of children in schools is to improve the effectiveness of their teachers. This can be accomplished in the case of mathematics teachers by improving their mathematics education in their initial training. *The immediate aim of this project is, therefore to find ways and means of improving the mathematics education of future secondary mathematics teachers in training.*

In the Irish context, a variety of considerations lead to the conclusion that the initial training of mathematics teachers for Irish secondary schools *needs* to be improved. Here, the emphasis is on the inadequacy of the prior education and training of mathematics teachers but other reasons may be adduced from the discussion of mathematics teaching presented in Chapter V. Despite new and pressing demands on the mathematics teachers in question, *there has been no significant change in the education of mathematics teachers for Irish secondary schools since the founding of the State.* Mathematics teachers are not alone in their plight. The Higher Education Authority [2] (p.2) had this to say in its report on teacher education published in 1970:

> (a) It seems to us that for the following reasons the present is a particularly appropriate time for reviewing the different systems of teacher training which have grown up in this country:
>
> (i) *No fundamental changes have taken place in such training generally since the State was founded.*
>
> (ii) Since about 1958 there has been an increased public awareness of the place of education in our rapidly changing society, an awareness intensified in the 1960's *when many new educational policies were adopted.* The general pace of social, economic and industrial development of the sixties and the acceptance of economic and industrial development of the sixties and the acceptance of economic and social planning (which will probably accelerate in the seventies and eighties, especially if this country becomes a member of the E.E.C)

will demand of our educational system a high competence, a new flexibility and an ability to respond and adapt quickly to cultural, social, economic and technological changes.

(iii) *The introduction of new curricula in the secondary schools* and the projected introduction of new curricula in the primary schools.

(iv) *The need to keep the contents of courses and educational technology abreast of modern requirements.*

(v) *The prospective increase in numbers of pupils coming into the primary and post-primary fields over the next ten years;* The additional numbers of teachers which will thus be needed and the increased specialisation which will be required of them.

[my italics]

The universities are largely responsible for the initial education and training of secondary school teachers in Ireland. This preparation is conducted along the consecutive model i.e. primary degree in chosen field followed by the Higher Diploma in Education, a post-graduate qualification in education. It is fair to say that the primary degree course in mathematics is directed towards future professionals in that field as are mathematics courses in the science degree programme, and as such *no attention is given to the specific requirements of future mathematics teachers.* Pedagogical training in mathematics is confined to the part-time Higher Diploma in Education course and this course is not *primarily* concerned with the pedagogy of mathematics. The Diploma course itself has met with severe criticism in recent years by students and teachers alike, and it did not escape the criticism of the Higher Education Authority in its report [2]. In view of the fact that the principal source of mathematics teachers for Irish secondary schools is comprised of graduates in mathematics, science, engineering and commerce and the only pedagogical training they receive in mathematics is in the Higher Diploma in Education course -

which is only compulsory for teachers in the private sector of the secondary system - there is serious cause for concern.

The supply of qualified mathematics teachers for Irish secondary schools has always fallen short of demand. Even accepting mathematics, science, engineering and commerce graduates as being 'qualified' the demand has not been satisfied. The point was highlighted in stark relief by the Investment in Education survey team [3] in 1965 when that team pointed out that only 44 per cent of the instruction in mathematics at secondary level was conducted by teachers with mathematics in their degree and as much as 19 per cent was conducted by teachers who had not taken mathematics at university at all. These figures were based on a sample taken in 1961/62 a period for which another indicator of the qualifications of mathematics teachers is available. In the Dail in 1963 Dr Hillery, then Minister for Education, stated that the total number of honours graduates in mathematics who entered teaching as registered teachers in the period January 1951 - 31 July 1961 was *twelve* and only *nine* were still in teaching in 1961/62 [4]. One would like to dismiss these figures as being out of date and irrelevant in the seventies but the Higher Education Authority felt a compelling need to refer to the same Investment in Education statistic in its 1970 Report on Teacher Education and went further to make a specific recommendation in this regard, namely, "newly recruited teachers should not be regarded as qualified to teach at senior cycle level a subject not taken in their degrees" [2] (p.22). The Irish Department of Education has generally adhered to this principle in the last few years but such a policy is unlikely to improve matters significantly in relation to mathematics teaching in the schools. At best it confines mathematics teaching to those with mathematics in their degrees. It does nothing to improve the qualifications of those in the system with anything from 0-40 years service still remaining. And besides the phrase 'mathematics in their degrees' is hardly a description of an adequate training for a modern teacher of secondary school mathematics even if such teachers were adequately supported by in-service courses which they are not in Ireland. Compare the Irish Department of Education description 'mathematics in their degrees' with the recommendations of the Committee on the Undergraduate Programme in Mathematics of the Mathematical Association of America and bear in mind that the Irish phrase is a current (1978) description and the American proposals refer to 1960 in the U.S. [5]:

(A) THREE courses in analysis
(B) TWO courses in abstract algebra
(C) TWO courses in geometry beyond analytic geometry
(D) TWO courses in probability and statistics
(E) TWO upper-class elective courses e.g. introduction to real variables, number theory, topology, history of mathematics, or numerical analysis (including use of high-speed computing machines).

One of these courses should contain an introduction to the language of logic and sets, which can be used in a variety of courses.

The Irish Department of Education principle is deficient in yet another important respect; in trying to provide for mathematics instruction at the senior cycle i.e. the last two years of secondary education, it draws attention and teachers away from the junior cycle i.e. the first three years of secondary education. Arguably it is here in the junior cycle that the best teachers should be deployed in order to create the right attitude and atmosphere for mathematics learning and the appropriate base for future mathematics learning. Clearly a problem exists in relation to the supply of adequately trained mathematics teachers for Irish secondary schools.

These difficulties have been compounded by new demands on mathematics teachers in Irish secondary schools in recent times. These demands have arisen mainly as a result of changes in educational policy. The changes are listed here without comment except to say that similar changes have provoked discussion and research in the U.K. but those which are peculiar to Ireland only obviously have ramifications for mathematics teaching and teacher education. They are in chronological order:

1. the introduction of a new principle of comprehensive education in 1963 followed by the opening of comprehensive and later community schools.

2. the introduction of a new mathematics curriculum in the mid-sixties.

3. discontinuation of selection for secondary education in 1966.

4. the addition of a vast third level superstructure of nine regional technical colleges and two technologically based National Institutes for Higher Education from 1969 onwards.

5. the addition of senior cycle to vocational schools from 1969.

6. the introduction of a new integrated child-centred curriculum in primary schools 1971/72

7. the raising of the school-leaving age from 14 to 15 in 1972.

These educational policies were implemented in a political climate concerned with national economic development, a development which has been explicitly acknowledged by government as being dependent upon education especially the type of education which contributes to technological development. *Yet despite all this no official attempt has been made to improve the initial mathematical training of mathematics teachers for Irish secondary schools.*

This thesis deals with the author's attempts to improve the initial mathematics education of future mathematics teachers for Irish secondary schools. The early chapters (Chapters II,III,IV,V) are devoted to a comprehensive analysis of the Irish educational scene including teacher education which is developed as a backdrop for the whole project. These chapters besides being descriptive define the working constraints on researchers in Irish education. The rest of the thesis carries one through three years of the author's innovative work in teacher education conducted under actual working conditions at Thomond College of Education, Limerick. Chapter VI deals with experiences at Thomond College including description and analyses of programmes which were run there and validated by external awards bodies in the period 1975-77. Chapter VII is devoted to an important experimental project in self-paced study conducted as part of the mathematics programme. The work conducted at Thomond College during those years led to a new synthesis - a synthesis which is encapsulated in the author's 'cultural approach' to mathematics. The case for this new synthesis is argued in Chapter VIII. The new rationale and its curricular implications for mathematics in Ireland are elaborated in Chapter IX. The thesis concludes with Chapter X which is devoted to presenting conclusions and recommendations, and exploring directions for further research. Throughout the thesis use is made of comparative material, especially from U.K. sources, in support of arguments and/or for description and amplification.

CHAPTER II

THE IRISH EDUCATION SYSTEM I : AN HISTORICAL SURVEY

Present day Irish education is intricate in its manifold parts, their institutional form and their interrelationships. The system as a whole defies simple analysis because of the complex of interests, parental, Church and State and the peculiar accommodation contributing to the system as a whole. A comprehensive understanding of the system at its present state of evolution demands an historical perspective. The evidence of history generates insight into factors contributing to the growth of the system as it is today. Current Irish educational issues are scarcely intelligible without this insight. The plan, therefore is to provide a historical survey followed by a general survey of the system as a whole as a prelude to a detailed examination of the system's components.

1. The Celtic Tradition

The history of Irish education begins in pre-Christian Celtic Ireland. The socio-political structure of that era, essentially aristocratic in nature, was based on the small district ruler or chieftain. A well-organized native Irish educational system arose in response to the needs of that society; an ancient society supporting a learned class boasting three important professional groups. It is in the education of this learned class that something akin to scholastic institutions is found. The origin of the lay professional school, a distinctive feature in Irish educational history is traced to these institutions. Distinct traditions arose in the professional schools in response to the professional pursuits of the learned class; traditions fostered in separate law, poetry and medical schools. From the standpoint of subsequent Irish history the fili and their poetry schools, later known as Bardic Schools, were the most important. The entire educative process in these institutions was based on oral repetitive learning. At first the fili were wandering teachers supported and protected by district rulers. Their status was enhanced by the last major reform of native Irish education, which occurred at the convention of Drom Ceata in 590. One of their numbers was appointed in each district as ollamh or professor supported by a land grant from the district king who guaranteed his personal safety; in return the ollamh was charged with giving instruction in Irish culture [6]. Permanent institutions grew up around these fili serving as prototypes of the Bardic Schools which survived until the seventeenth century. The characteristic form of native Irish education was thus achieved.

Fundamental to the entire educational system and the education of all classes during this period was the system of fosterage, a practice which was continued in Ireland until the nineteenth century. This was a system whereby every male child was entrusted to a family of equal or lower status to be kept by the foster parents and instructed by them in a manner appropriate to the child's status in society [6]. Such a system preserved the class distinctions inbuilt in the society providing as it did an aristocratic education when appropriate, and in other cases training in husbandry and crafts for the peasants. The system, therefore, mirrored the early Irish society such as it was.

Prior to the advent of Christianity in Ireland in the fifth century the country's political and social structure was decentralized. Native Irish society was highly stratified ranging from king to peasant with the fili somewhere between. The course of conversion was smooth and rapid due to the lack of major conflict between the values of Christianity and those of native society. The pagan priests i.e.the Druids were replaced by Christian clergy but native learning and institutions continued as before and in parallel with monastic schools which were founded by the Christian monks. Monastic schools were primarily concerned with the training of young men for the priesthood but developed a tradition of scholarship in Latin and in native culture. The study and use of Latin, a new cultural agent in native society, dates from this period [7].The monks introduced a tradition of written work which sets them apart from the lay professional schools where writing was not used although writing was used in Ireland prior to Christian times. The curriculum was wholly informed by religious principles and based entirely on the study of the Bible [6]. These schools provided a second level education and beyond and are generally held to have fulfilled the role of universities especially in medieval Ireland, a period in Irish educational history notable for the absence of university institutions. Educational institutions of this period must not be construed as providing education for the masses. They were providing education for aristocratic families interested in perpetuating their class and consequently the presence of poor scholars was more the exception than the rule.

2. The Course of Irish Learning from early Christian Times to the Middle Ages

Ireland earned a reputation for learning in Europe based primarily on monastic schools and great scholar-monks during the period from the sixth to the eight centuries. But the course of Irish learning was severelycurtailed by the Danish invasions from theninth to the eleventh centuries. The political system based as it was on local autonomy fostered education during peacetime but severely limited the nation's ability to act in a concerted manner against the invaders thus contributing effectively to the decline of learning in this period as the rich monasteries were invariably sacked by the Danes for their treasures. This provoked an exodus of monks to the Continent seeking safe refuge causing a double loss to Irish education in the loss of places and facilities for learning and loss through death or flight of renowned teachers. A revival of learning in monastic schools took place after the Danes were decisively defeated at Clontarf in 1014. Many famous monastic foundations reached their zenith as scholastic institutions during this revival including Armagh and Clonmacnois. It was decreed at the Synod of Clane (1162) that only graduates of Armagh would be permitted to teach in Monastic shcools thus confirming the pre-eminent position of Armagh as a place of learning [6].

Ireland's respite from foreign aggression was short-lived. Norman incursions by English-based lords were commonplace in the latter half of the twelfth century. Initially, no organized conquest of the whole country was attempted. Norman rule existed in some parts of the island but there was no religious persecution since the invaders were of the same faith as the Irish. Monastic schools continued to flourish, some under Anglo-Norman influence and some under native Irish control. The Normans founded their own schools in population centres around their Castles and Anglo-Norman town schools first appeared in Ireland during this period. The lay schools continued uninterrupted for the most part, by now displaying a feature peculiar to Irish education namely, the preponderance of family schools based on a family tradition of learning in a specific field e.g. poetry, medicine or law. A large measure of cross-fertilization existed between the monastic and lay schools and with the later decline of monastic schools the classical tradition was preserved in the native schools [8]. The early Norman settlers constituted no threat to native Irish culture. However, the situation changed drastically from the time of the English sovereign Edward 1 (1272-1307) when the conquest and ultimate subjugation of the whole country became the paramount goal. It is from this period *that Irish history became inextricably intertwined with that of its neighbour, England.*

An Anglo-Norman invasion of Ireland had been urged many times by different Popes to bring the Irish Church into conformity with Rome [9]. Henry 11 used the Papal exhortation as an excuse to invade Ireland. Medieval times was a period in which holy wars were an excuse for conquest and Papal approval was sought as much for political advantage as for spiritual blessing. The total permanent subjugation of the Irish people proved to be an elusive objective for a succession of English monarchs. The greatest single factor, apart from hostile action, militating against sustaining English rule in Ireland, was the total cultural assimilation of the Anglo-Normans into the host culture. Measures were enacted to prevent this occurrence, the most notable being the framing and enactment of the Statutes of Kilkenny (1366) to prevent settlers from abandoning the English language, laws and customs. There was a clear intention in the Statutes to use the Church as an anglicizing influence on the native Irish [6]. Church benefices and positions in religious communities were denied the Irish. In 1381 Richard 11 requested the Pope to insist on fluency in English for Irish clergy appointed to benefices and Irish prelates were to be charged with responsibility for ensuring that their subjects learn English. So it became English policy to attack native Irish culture and to use the Church as a political weapon against the Irish people. It was not long before education came to be seen in the same light. Henry V111 combined in his Reformed Church i.e. the Anglican Church the twin weapons of evangelization and education against the native Irish. The Anglican Church was extended to Ireland by the Act of Supremacy in 1536. Henry ordered the dissolution of Irish monasteries in 1537 thus depriving the country of its monastic schools within a few years. The dispossession of the native patrons after the Battle of Kinsale (1601) led to the demise of the lay schools. Military conquest was quickly achieved and effective political control extended over the whole country before the end of the seventeenth century. As Professor Ryan so aptly put it [8]:

> Our country was to be one with England in politics one in religion, one in culture, was to cease therefore, to be Gaelic, was to become thoroughly Anglicised and eventually Protestant.

A country devoid of native educational institutions and under control of a foreign power could hardly resist such a policy.

3. State Intervention in Irish education - Tudor Policy, and the Penal Laws

The year 1537 marks the beginning of a new era in Irish education. The Tudor government intervened in a positive way to direct education in Ireland. The Dublin Parliament passed an Act (28 Henry V111) in 1537 requiring the establishment of parish schools to teach English and the English religion [7]. This Act signals the beginning of the practice of *direct legislative intervention in Irish education and is the first recorded attempt to set-up a State sponsored elementary school system in Ireland.* Successive English administrations demonstrated a great willingness to intervene statutorily in Irish educational affairs. Akenson includes this practice as an important contributory factor in the early emergence in Ireland of a State-supported national system of Education [10]. Henry's Act proved ineffectual for a variety of reasons not the least of them being lack of financial resources and the absence of effective political control. There was also competition from the Catholic clergy. There is another sense in which the Act is significant; *from then onwards the political policies of English governments determined the shape of Irish education.*

The attempt to establish grammar schools in each diocese during the reign of Elizabeth 1 may be seen as the second phase in the Tudor policy in education. In 1570 the Dublin Parliament made statutory provision for a system of grammar schools under Anglican episcopal control. The provision of Diocesan schools, as they came to be known, was a first step towards the training of native clergy for the Anglican Church, these schools being an avenue to higher education. The policy was crowned in 1591 when an Anglican university, Trinity College was founded in Dublin by Royal Charter [11]. If the Anglican Church was to be other than an alien institution in Ireland, it was necessary to educate a native clergy. These efforts at increasing Anglican influence in Irish education brought with them concommitant efforts aimed at reducing Catholic i.e. native control. Catholic teachers were placed under legal disabilities. Later Cromwell's government ruthlessly stamped out native opposition. Finally, towards the end of the seventeenth century the Penal Laws were passed debarring Catholics from any kind of teaching.

An underground system of education was the inevitable consequence of repressive measures enforced under the Penal Code. A society with a long tradition in native and classical learning and possessed of a great desire for education could not be effectively denied education. The Hedge schools conducted in the open, in mud huts or in ditches, by outlawed teachers carried on the tradition of learning during Penal times. These clandestine schools were popular and widely supported. The quality of instruction was variable depending upon the schoolmaster and the curriculum was based on reading, writing and arithmetic. The system combined both elementary and secondary education, some schools gaining a reputation for classical learning and mathematics. Religion was an important subject in these schools and was taught in collaboration with the local parish priest. The system was perpetuated by the pupils who contested with teachers before being deemed worthy of the status of schoolmaster [9]. Teachers were paid by pupils or the local priest and hence the designation 'pay school'. Higher education was denied Catholics during this period as long as they remained in Ireland and Catholic. However, the Penal Laws were largely circumvented by sending students to the Irish Colleges on the Continent founded in order to provide higher education for Irish students as well as priests for the home mission. Some notable Irish Colleges were associated with Louvain, Lisbon and Salamanca. These colleges diminished in importance after the Relief Acts of 1782 and 1792 which signalled a relaxation of the Penal Code [11]. Ireland survived the three-pronged attack mounted by the English and codified in the Penal Laws namely, those laws aimed at the Catholic hierarchy and priests, laws denying Catholics access to trades and professions and punitive laws penalizing Catholics for being Catholics [10].

4. The Education Societies and the Catholic Church

Two opposing forces were at work in Irish education in the period following upon the relaxation of the Penal Laws and ending with the introduction of a state-aided national system of education in 1831. A distinctive feature of education in the period was the existence of Protestant education societies, voluntary state supported agencies determined to carry a 'second reformation' to Ireland. During the same period Catholic institutions had evolved along two different lines. Pay schools run mainly by private individuals were heirs to the hedge school tradition. The second category of Catholic schools included schools run by parish priests and supported by parish monies, girls schools attached to convents and boys schools founded by the Christian Brothers [12]. All Catholic schools were private and without state support. The period is notable for efforts by the Catholic hierarchy to counteract the effects of the education societies. The Catholic hierarchy vigorously condemned the activities of these societies and agitated for a state-aided system of schools that were religiously neutral [10]. The period coincides, although not accidentally, with a growth of activity in Catholic education attributable mainly to religious teaching orders of priests, nuns and brothers. This increased activity may be seen as a direct response to proselytizing of the education societies. It was a particularly appropriate response in the circumstances. An impoverished people suffering social and political disadvantage could not support an expensive system of education. Religious teaching orders were easy to deploy, demanded no salaries, arranged their own teacher-training and offered a staunch bulwark against proselytizing agencies [6]. The period is also notable because of the emergence of the Ursuline, Mercy and Presentation Sisters and the Christian Brothers. It is safe to assume therefore, that in the period immediately before 1831 most Catholic children were receiving an elementary education.

5. Some Important Contemporary Political Developments

It has been indicated previously that English policy in Irish education was motivated more by political consideration than genuine educational concern. A significant political change from the point of view of subsequent Irish educational history occurred in 1800 namely, the abolition of the Dublin Parliament and the imposition of direct rule by England under the provisions of the Act of Union. English policies were to be implemented in Ireland by an Irish administration under the Lord Lieutenant and an Under-Secretary known as the Chief Secretary for Ireland. The bureaucratic arrangement and successive chief secretaries viewed together, considerably influenced the course of Irish education. The campaign for Catholic Emancipation was won in 1829 opening the way for full participation in Irish social and commercial life by Irish people. This in turn had repercussions on the consciousness of the populace as a whole. Attention was focussed on education and it was sought as a means to advancement in the professions newly opened to Catholics.

6. The National System of Education

The major educational issue of the day in Ireland, an issue not without grave political implications, was the question of the provision of elementary education for all Irish children. Many factors combined to provide a climate of opinion in Ireland which supported the idea of a national system of education. An official consensus existed as to how a state system should be constructed chiefly as the result of the labours of numerous commissions of inquiry into Irish education and notable individuals such as Thomas Wyse. The need was acknowledged generally, by English and Irish alike. The overwhelming majority of poor people showed a great desire to have their children educated. The Catholic Church while preferring denominational education saw that an undenominational state system was the only alternative to a state-supported Protestant system at that time. The time was opportune for Stanley, the Irish Chief Secretary, to introduce such a system and in 1831 he did so. The system of national education instituted by Stanley was funded by an annual grant voted by the English Parliament for that purpose. The system was administered initially by a board of seven unpaid commissioners known as the Board of National Education Commissioners. Stanley's letter to the first Board served as the written constitution for the National system. The guidelines contained in the Stanley letter came to be known as 'instructions' and they could not be changed without the approval of the Lord Lieutenant. It is noteworthy that the system was established by letter and not by statute and subsequently administered under the terms of that letter. Accordingly, the system was to be mixed or undenominational in character, state aid to be granted subject to certain conditions including inspection. Teachers were to be trained in Model Schools set-up and administered directly by the Board for that purpose. Local managers retained the right to appoint and dismiss teachers in their schools. The system took root quickly and in a relatively short period it was indeed national in character catering for approximately half a million pupils in some 4 500 schools throughout the country [10].

Although undenominational in theory the National Schools as they came to be known, *were denominational in practice.* Circumstances contrived to make this so. Local managers were usually clergymen acting on behalf of their co-religionists thus ensuring the denominational character of the student intake. The denominational aspect was preserved by the power of the manager to appoint and dismiss teachers. The majority Catholic population was greatly favoured by these circumstances as a great many schools had only Catholics on their rolls thus ensuring Catholic control. The national system was resisted by all denominations in Ireland because it sponsored only mixed or un-denominational education. The Anglican resistence found institutional form in the Church Education Society, a voluntary body providing an alternative for Anglicans [12]. But competition from the National system was too great and by 1860 the Anglicans succumbed and joined the system. The Presbyterians were fiercely antagonistic from the outset but eventually participated under a compromise formula [10]. The Catholic hierarchy's posture changed from a benign acceptance in the beginning to an outright condemnation of undenominational education issued at the Synod of Thurles in 1850. This stance directly reflected the growing power of the Catholic hierarchy over the national system of education. The National Board of Education was challenged by the hierarchy on the issue of teacher training. From a denominational point of view the training of teachers was a crucial matter second only to religious instruction of pupils. The issue was resolved in favour of the hierarchy when the English government ordered the Commissioners to recognise denominational teacher training Colleges [7]. Several colleges were established and some remain in existence today performing the same function. By the turn of the century the Catholic hierarchy exercised an effective measure of control over the system through ownership of schools and teacher training colleges and through its influence over Catholic pupils and teachers.

The curriculum for National schools was laid down by the Board and its acceptance was a condition for aid. It was organized around an obligatory core of reading, writing and arithmetic but Grammar, Geography and Needlework were also taught. *Mathematics and Science were regarded as extras and thus rarely taught.* The Board provided its own series of textbooks which were of a high standard and used widely throughout the system. In general sanction of the Board had to be sought for all books in use during normal school hours. Major changes were introduced after the Powis Commission on Primary Education in Ireland reported in 1870. The Commission recommended the introduction of the 'results system' whereby fees were paid to teachers on the results of the individual examination of pupils by inspectors [7]. There was an examination programme for each standard which included reading, writing, arithmetic, agriculture (theory) for boys - and needlework for girls. This system remained unaltered until a revised programme was introduced by the Resident Commissioner, Starkie, in 1901. Payment by results was abolished and English and Arithmetic became obligatory in all schools as did other subjects where there were teachers to teach them. Although basically literacy schools, literacy was achieved in the English language. The system therefore, had a negative effect on the Irish language. This is not surprising since the National System of Education was essentially an English school system superimposed for better or worse on the Irish nation [12].

7. The Genesis of Secondary Education in Ireland

The nucleus of a secondary school system had evolved by the end of the eighteenth century. In 1791 there were forty-six Protestant schools claiming to provide a grammar-school type of education for a total of not more than 1 200 pupils [12]. Collectively these schools were known as 'endowed schools' because of their origins and method of funding. They were supported by public endowment of confiscated lands. Their lineage descended from three distinct sources, namely Elizabeth's Act in 1570 was responsible for the establishment of grammar schools and *was the first attempt by the State to establish a system of secondary schools in Ireland* [11]. These were projected along diocesan lines under the control of Anglican bishops and became known as Diocesan Schools. The Stuart plantations in Ulster and Leinster early in the seventeenth century were the occasion for another distinct effort to establish grammar schools in Ireland. James 1 founded Royal Schools in Dungannon

(1614) Enniskillen, Cavan and Armagh so as to perpetuate Protestant domination in the planted counties. Pursuing the same policy objective Charles 1 created a second set of Royal Schools and in 1629 schools were established at Banagher and Carysfort, followed by Clogher in 1632 [10]. Banagher excepted, all were grammar schools. Charles 11 founded a Royal School at Raphoe in Donegal. Responsibility for Royal Schools was in the hands of Anglican bishops from their inception and they were supported by Royal endowments of confiscated lands. The Erasmus Smith Grammar Schools were also founded and maintained by public endowment with schools at Drogheda, Galway, Ennis and Tipperary after 1641 [13]. A third group of secondary schools were maintained in towns by progressive town commissioners or private individuals. All these schools were Protestant foundations specifically maintained for the education of the minority Protestant ascendancy. The statistics indicate that only a privileged minority aspired to a secondary type education in Ireland during this period.

Initially protestant activity in the field of intermediate or secondary education far outstripped that of Catholic enterprise. Catholic progress in intermediate education was only possible after the relaxation of the Penal Laws. Without state aid and dependent upon private initiative the number of Catholic foundations grew but slowly at first. The efforts of Catholic religious contributed significantly to the growth of private intermediate schools. Diocesan colleges were founded by Catholic bishops; each had an ecclesiastic department for the education of youths for the priesthood [14]. By 1820 there were seven Diocesan Colleges. The Powis Commission reported the existence of fifty-five Christian Brothers schools in 1869, almost all offering courses of a secondary nature. In all forty-seven Catholic intermediate schools came into existence in the period between the Relief Acts and 1870. Intermediate education for girls was not neglected as evidenced by the work of the Ursuline, Presentation and Mercy Sisters, but in common with most other countries was comparatively rare until after 1850. Total participation in what might be termed intermediate or secondary education as recorded in 1871 was a mere 24 170 out of a population of 5 412 337; these figures include 12 274 Catholics out of a Catholic population of 4 150 867 [11]. The relevant statistic per thousand of population showed three times greater participation by Protestants in intermediate education than their Catholic counterparts.

No attempt was made by the State to restructure intermediate education in Ireland. Instead state aid was made available to all intermediate schools for the first time under the provisions of the Intermediate Education Act (1878). The extent of state subvention was limited by the size of the fund placed at the disposal of the Intermediate Education Board established under the Act. State endowed schools retained their endowments as well as sharin g in monies disbursed by the Board. Schools received aid on the basis results obtained in public examinations of the Board. The 'payment by results' system thus established was to have a formative and lasting influence on the nature of secondary education in Ireland. The emphasis on examinations based on the Board's prescribed syllabuses gave the whole curriculum an *examination bias*. The system was not without shortcomings. The Commissioners themselves were critical of the system and agitated for change. The single subject basis for examinations was changed to a system of subject groups by the Intermediate Education Act (1900). This Act empowered the Board to appoint inspectors but due to financial strictures none were appointed until 1909 [11]. The method of payment by results was replaced by inspection grants in 1913 and statutory provision for a register of intermediate teachers was made in 1914. The Commissioners continued to press for improvements but were overtaken by political events leading to the Irish Free State. The effect of the original Act was to confirm *the denominational character of Irish intermediate education and to consolidate it under private control of the respective churches.*

8. Technical Education - The Beginnings

Non elementary school technical education long officially neglected in Ireland and consequently confined to the activities of voluntary groups made little progress in the early nineteenth century. Groups were active in art education especially, and Limerick boasted a School of Art in 1852; Cork had a School of Art and Design since 1848. A handful of Mechanics Institutes lay scattered around the country notably in Belfast, Dublin, Cork and Clonmel. But decisive State intervention in aid of technical education did not materialize until the establishment by Act of an Irish Department of Agriculture and Technical Instruction in 1900 with responsibility for initiating a system of technical education suited to Ireland [11]. Authority to administer grants for the teaching of Science and Art was transferred to this department from the Department of Science and Art in London, the successor to the original Department of Practical Art set-up under the Board of Trade in 1852. Technical education in

Ireland prospered under the new department. This was due largely to the initiative and common sense approach of its officials. Technical schools under the aegis of the Department were secular institutions and local involvement in their management was encouraged. This involvement was based on the administrative form given to Ireland under the Irish Local Government Act (1898) which provided a complete system of local government along the English model [10]. The Agricultural and Technical Instruction Act (1899) built on this Act by empowering local councils to form education committees to plan programmes in technical and agricultural instruction. Funds raised by the rating authority on the rates were supplemented by the Department for the purposes of education and local committees directly supervised their own schools. Forty-nine local committees were set up and many permanent technical schools were established in urban centres [13]. Apart from their need and obvious success the technical schools were quite distinct in Irish education because of the measure of local control afforded their lay management committees. The many technical schools operated under the Department but were directly controlled by their local committees which planned suitable programmes of instruction in conjunction with the Department's officials and then implemented the programmes in their schools.

9. Educational Development 1900-1922: A Major Shortcoming

The development of education in its many aspects during the first two decades of the twentieth century is remarkable for the lack of coordination or indeed serious attempts to coordinate the activities of the various education boards. Three separate education boards were pursuing their own policies *with little reference to each other or to* *the newly created Department of Agriculture and Technical Instruction.* No effective liaison existed between the Commissioners of National Education, Intermediate Education Commissioners of the Commissioners for Endowed Schools. The Intermediate Education Board adopted the Department's programme in Science and Drawing as well as examination and inspection, thus initiating some coordination if only of a limited nature. Attempts at coordinated action across the whole educational spectrum were confined to dual and triple membership of education boards by individual commissioners but this led to little change in operation. Technical education prospered during this period but the same cannot be said of National or Intermediate education. Primary education suffered a malaise brought on by lack of local involvement and low attendance rates. No public scholarship provision existed for pupils transferring to intermediate schools. Meagre financial resources had always restricted the activities of the Intermediate Education Commissioners but by this time the 'payment by results' scheme was having a decidedly adverse affect on intermediate education in that the curriculum was unnecessarily restricted and examinations oriented. Another cause for concern was exhibited in the treatment of teachers. Teachers fared very badly in respect of renumeration, pensions and security of tenure which in turn had a debilitating effect on the system as a whole [15]. The existing all-Ireland administration failed to resolve the many problems despite the constructive recommendations of vice-regal commissions on intermediate and primary education at the close of the second decade thus ensuring that the same problems were part of the inheritance of the new independent Irish state.

10. University education in Ireland - A Brief Summary of its Development

The Irish University question was resolved early in the twentieth century with the passing of the Irish Universities Act (1908). This had been a vexed question of long standing having to do more with politics than the higher educational needs of the country. Trinity College, the only college of the University of Dublin served as the sole university institution in Ireland from 1591 until the close of the eighteenth century. An Anglican university established for the purpose of providing higher education for Anglican churchmen, it was extremely sectarian at first but later allowing Presbyterians and Catholics to study there. Although Trinity continued as a viable institute Presbyterian and Catholic alike sought alternatives - the former looked to Scotland and the latter to Maynooth founded in 1795 as a seminary for the training of priests. Subsequently, Maynooth received state aid under the provisions of the Maynooth Act (1845). All efforts by the English government to provide undenominational university education were opposed by the Catholic hierarchy who were determined to settle for nothing short of a Catholic university. This denominationalism greatly retarded the development of university institutions in Ireland [12]. Translated into action it meant an effective boycott of the Queen's Colleges in Belfast, Cork and Galway established under the Provincial Colleges Act (1845). The colleges fared badly without Catholic students. They were linked together as constituent colleges of the Queen's University in 1850 which in turn was replaced by the Royal University in 1879. The Royal University was a purely examining body allowing all irrespective of religion to sit for its examination; as such it received a fair measure of support. Support was readily received from the students of the Catholic University founded in Dublin by the Catholic Hierarchy in 1854.

Cardinal Newman served as its first Rector but despite such an auspicious beginning was nevertheless a failure unable to secure a charter to confer degrees from the government. The Catholic University continued to accept students and was transferred into the care of the Jesuits in 1883 having been reorganized into University College, Dublin in the previous year. The Jesuits maintained the college until 1908. Under the provisions of the Irish Universities Act (1908) the Royal University was dissolved and two new university institutions created. Queen's College, Belfast was elevated to university status and designated Queen's University, Belfast. The Queen's colleges of Cork and Galway together with the University College Dublin were federated as constituent colleges in the National University of Ireland with St Patrick's College, Maynooth affiliated as a recognized college [6]. Maynooth occupies a dual role as a recognized college of the National University and as a Pontifical University conferring degrees in Philosophy, Theology and Canon Law. This left Ireland with three universities, namely, an independent Trinity College, Queen's University and the National University of Ireland.

11. Education in the Irish Free State - the Transition Period

The close of the second decade and the opening years of the third decade of the twentieth century are marked in Irish history by political events culminating in the founding of the Irish Free State. Educational matters were for the moment submerged, though not forgotten as evidenced by the setting up of a special commission on secondary education by the Second Dail in 1921. The Government of Ireland Act (1920) partitioned Ireland into two states, Northern Ireland and the Irish Free State, the latter evolving into the Irish Republic or simply Ireland.

The administration of the educational services for the Irish Free State was taken over by the Provisional Government on 1 February, 1922 [11]. Simultaneously full powers over education in Northern Ireland were transferred to the Ministry of Education of the Parliament of Northern Ireland. From then onwards each state pursued separate policies in educational matters, the North closely allied to the United Kingdom while the South evolved its own system after independence.

In the South administrative and curricular reform was forthcoming during the transition period but significantly no structural reform of the education system was attempted. Responsibility for the three education boards passed to the Minister for Education in the Provisional Government who abolished all three boards and concentrated their functions for the time being in the hands of senior civil servants. Reorganization proceeded under the government of the Irish Free State which had replaced the Provisional Government. Under the provisions of the Ministers and Secretaries Act of 1924 administrative reorganization of education was effected by centralizing the educational services in the Department of Education which was now responsible for national (renamed primary), intermediate (renamed secondary) and technical education.[16]. Agricultural education remained outside the control of the Department. In addition the Minister for Education was charged with responsibility for Reformatory and Industrial Schools, the National Museum, National Library of Ireland, National Gallery and the National College of Art [16]. This represents the first occasion in Irish history that the policy and administration of education in Ireland was the immediate responsibility of a Minister of State accountable to the State Parliament. On the other hand it is important to note that the State did not extend its powers over existing primary and secondary schools *thereby confirming its acceptance of British educational institutions and practices*, an exception being the ending of the 'payment by results' system in secondary education under the provisions of the Intermediate Education (Amendment) Act of 1924. A new system of capitation grants replaced the old system. *In short, centralization of educational services was the chief administrative reform; a centralization which became more extreme during the following decades.*

Curricular reform in the primary schools became confused with the political objective of the revival of the Irish language which was to be pursued through the primary schools. Little thought was given to the educational merit of such an approach. Whatever the reasons the schools became the vehicle for the proposed Gaelic Revival and primary schools were of paramount importance in such a venture. The secondary schools were also involved but to a lesser degree. The importance accorded the revival of Irish language and culture is underlined by the attention given it at the First National Programme Conference in 1921 and by the appointment of the Gaeltacht Commission in 1925. Its report issued in 1926 was aimed at improving the position of Irish by incentives and bonuses. The First National Programme Conference convened by the Irish National Teachers Association in 1921 devoted much time to the question of Irish in the primary schools. Ideally it was felt that Irish should be taught to all school children in primary schools for at least one hour per day and all the work in the two infant grades should be conducted through the medium of Irish. The Conference criticized the existing programme because of the large number of obligatory subjects and the neglect of the Irish language. The proposals of the Conference were adopted provisionally by the Provisional Government's Minister for Education in April 1922[17]. The impetus for reform continued and the Minister for Education was obliged to convene the Second National Programme Conference which was representative of teachers, professors, Dail and Senate, and County Councils. Its report issued in 1926 and adopted by the Minister set out the lines along which primary education in Ireland subsequently developed. The programme for primary schools approved in April 1922 included an obligatory core of Irish, English, Mathematics, history, geography, singing, physical training, and needlework. The Second National Conference approved the findings of the First conference but added some riders of its own. The curriculum introduced after the Second National Programme Conference included an obligatory core of religion, Irish, English, arithmetic, history, geography, music and needlework (for girls). *Rural science, algebra and geometry were obligatory in certain circumstances but never in one-teacher schools* [7]. The earlier position on Irish was softened and only where teachers were competent were infants to be taught entirely through Irish, otherwise children were to be instructed in Irish at least one hour per day. The emphasis on Irish in schools and the shortage of qualified Irish teachers forced the government to take special action. Six preparatory Colleges were opened in order to provide an adequate supply of fluent Irish speakers for the Teacher Training Colleges which in turn were obliged to reserve a percentage of available places for candidates coming from the Preparatory Colleges. Thus no effort was spared to advance the Gaelic revival in the schools. *Irish as a subject was* *elevated from a position of relative insignificance to occupy the preeminent place in the curriculum.*

Curricular reform extended to Intermediate Education during this period of transition. A Dail Commission on secondary education sat during 1921-22 and formulated the basis of the programme for Secondary Schools adopted in 1924. Junior, Middle and Senior examinations of the Intermediate Education Board were replaced by two examinations namely, the Intermediate Certificate and Leaving Certificate Examinations. Junior pupils would henceforth pursue a course of 3-4 years duration and senior pupils a two-year course, thus replacing the academic unit of one year adhered to by the Intermediate Education Commissioners. Each secondary school had to provide instruction in Irish, English, history and geography, mathematics, science or a language other than Irish or English; or commerce. Provision had to be made also for singing, physical training or games and Domestic Science for girls. Senior pupils had to present for at least five subjects of which Irish was compulsory while junior pupils were required to study at least six subjects including Irish, mathematics, history and geography and a second language. Prescribed text books were abolished and each teacher was allowed considerable freedom in drawing up his own programme subject only to approval of his inspector. It is important to note that *no structural change in the system was made due mainly to the private character of the secondary schools.* The Department's efforts were aimed at removing educational obstacles for those wishing to pursue their education from primary through secondary and onto university level. An entrance examination was introduced for those wishing to proceed from primary to secondary school [11]. Financial barriers still existed and only token efforts were made to remove them. A rate of one penny in the pound was authorized by the Dail in 1921 to provide local authority scholarships for entry to secondary or technical schools. This provision was confirmed by Local Government (Temporary Provisions) Act of 1923. Intermediate scholarships were awarded in 1924-25 by the Department on the basis of the results of the Intermediate Certificate Examination in order to aid pupils on their leaving certificate course. The combined number of scholarships available was altogether inadequate and remained so for many years. Thus the pattern of secondary education was set and continued without fundamental change until very recent times.

Technical education was not neglected during this period and was destined to be examined closely by a special government commission. At first consigned to the authority of the agriculture ministry, technical education was later transferred to the Department of Education under the terms of the Ministers and Secretaries Act of 1924. The government appointed a commission to enquire into technical education in the Irish Free State, and the Commission on Technical Education held its inaugural meeting in October 1926. The Commission's recommendations were incorporated into the Vocational Education Act of 1930. Under the provisions of the Act local authorities were required to set up Vocational Education Committees to provide and maintain schools and facilities for technical education in their localities. They were empowered to award scholarships and fix fees and required to strike a rate to finance vocational education in their administrative area [18]. In addition to technical education the Vocational Education Committees were charged with responsibility for providing 'continuation' education in general subjects for pupils who left primary school at fourteen. The Act improved significantly the position and state of technical education in Ireland by regularizing its financing and control. But of more significance was the provision under the Act of a second form of post-primary education, namely, continuation education in vocational schools. This education was more practical and less academic than secondary school courses and less expensive. *The Act itself marks the first time that an Irish Government regulated and controlled school education by statute and the Act is still unique in this respect, even today.* This sector continues to operate under the general control of the Minister for Education but the administration of the Act is the duty and responsibility of local education committees elected for that purpose.

The efforts of the new independent state to organize and coordinate the educational systems it had inherited were praiseworthy and not without desirable effects but no fundamental structural changes had been attempted. *By 1930 the tenor of education in an independent Ireland had been set.* Primary education continued as before, the National Education Commissioners having been replaced by the Minister for Education. Ownership, financing and control of primary schools remained largely unaltered as did the curriculum except for the position of Irish. Secondary education remained firmly in private hands, a position which the State was more than willing to accept and confirm. 'Payment by results' had been replaced by capitation grants and the State contributed to teachers' salaries. Compulsory education was introduced and for the first time effectively monitored under the School Attendance Act (1926), eliminating a nagging problem which had bedevilled the previous administration. The Vocational Education Act (1930) improved the position of technical education, and in many ways this sector continued to be the exception to the educational rule in Ireland: vocational schools were ostensibly undenominational and controlled by lay management committees and the whole system was and still is regulated by statute. Efforts at coordinating the three separate systems were confined to the curriculum and the removal of educational obstacles. The state introduced an entrance examination to secondary education which was compulsory for all intending pupils; the absence of such an examination was considered a defect in the old system. Some scholarship aid was provided for the first time. In spite of this government activity in education little real coordination existed between the three systems viz. primary, secondary and vocational. At third level the solution to the university question embodied in the Irish Universities Act (1908) proved more durable than anticipated and the new state found itself with an adequate system in the National University of Ireland. Queen's University, Belfast was transferred to the jurisdiction of the Ministry of Education in Northern Ireland, but Trinity College, Dublin continued an independent university in the Irish Free State. The teacher training colleges remained firmly under denominational control. It would seem therefore that education in the Irish Free State suffered no revolution in spite of the political upheaval attendant upon the founding of the State.

12. The Irish Free State-Isolationism, Conservatism and Education

During the early years of self-government the Irish Free State was preoccupied with internal affairs and little active contact with the outside world was maintained. The survival of the State was in doubt because of economic and political pressures. The Irish economy based as it was on agriculture was depressed by the world recession in 1929 and the years following. Matters were exacerbated by the economic war with Britain in the thirties. Political unrest contributed to the general dissatisfaction and unsettlement of the people. On the political front the nation's politicians were concerned with breaking the last political links with Britain. The State had accepted dominion status under the terms of the Anglo-Irish Treaty. Under External Relations Act (1936) the Irish Free State entered into an external relation with the British Commonwealth; formal links were ultimately severed when the Irish Republic was formally inaugurated in April 1949. The Irish Free State adopted a new constitution in 1937 thus replacing the constitution of 1922. The new constitution was remarkable in that it effectively established the Irish Free State as a republic in all but name and succeeded in bringing much needed stability to the country [12]. The country's self-isolation was accentuated by World War 11 and Ireland's policy of neutrality. It is not surprising therefore that the course of education during the thirties and forties remained uninfluenced by developments in the world at large.

Isolation fostered inward-looking institutions and extreme conservatism was the order of the day in education, for example, 1940 saw a voluntary negation of the liberal spirit in secondary education introduced in the new programme in the return to prescribed texts for schools. In that year the Department of Education reintroduced set texts for English, Latin, Greek and modern languages; Irish was included in the following year. In the primary schools the Department pushed ahead with the Government's Irish language revival programme. Progress was slow and in 1934 the Department intervened directly. Teachers agreed to place more emphasis on Irish and in return the Department reduced the standards previously held for other subjects in the curriculum. Significantly Rural Science was no longer obligatory, and algebra and geometry became optional under certain circumstances and in all classes taught by women [15]. Emphasis on Irish in the curriculum was maintained by the introduction of the Primary Certificate, a primary schools leaving certificate in 1928-29. At first this examination was optional and tested pupils in a range of subjects including Irish. Few pupils sat this examination until it became obligatory for Standard Vl pupils in 1943. The examinations subjects were reduced to three viz., Irish, English and arithmetic. The element of compulsion ensured that Irish, an examination subject, received due attention. Generally speaking the primary school programme remained substantially the same except for minor modifications recommended by the Council of Education which reported in 1954. The appointment of the Council of Education in 1950 may be seen in retrospect as one of the most significant developments in education in Ireland until then, since the founding of the State. The fact that almost thirty years had elapsed before the government felt compelling need to examine the education system or any sector of it, in itself attests to the conservatism in Irish education during those years and if further evidence were required then the Council's report in 1954, ignoring internationally accepted educational theory and practice and accepting the system of primary education as it was, is sufficient.

If little forward movement was evident during this period in primary education then it is true to say that less was visible in secondary education. The general complacency was not shattered until the severe and accurate criticism of Professor O'Meara in the late fifties[19].
Matters here were complicated by the fact that almost all secondary schools were under private control. The government discharged its statutory obligation under the Intermediate Education (Amendment) Act 1924 by aiding recognized schools with capitation grants and payment of teachers' salary increments. But no government assistance was forthcoming for buildings or repairs. The government interpreted its duty to be the provision of free elementry education for all its citizens but felt *no obligation to accept the onerous financial burden of extending secondary school facilities either in terms of increasing pupil places or improving buildings or equipment.* Thus schools were obliged to supplement their main source of income i.e. capitation grants by whatever means available and inevitably secondary schools levied fees. Private religious bodies, invariably Catholic, carried the burden of secondary education through the thirties and forties and on into the early sixties. The building of new schools was slowed because it was left entirely to the initiative of the school manager who had to provide the building, equipment and teachers before State grants were available. The absence of capital investment in secondary education by the government during these years had other far reaching effects on the system. School buildings became run-down and subjects requiring capital investment in equipment were grossly neglected e.g. science. The geographic and demographic distribution of schools lacked the overall coordination of an overseeing national agency such as the Department of Education. Together these things contributed to a

system of secondary education which was socially discriminatory in at least two aspects in that it was fee-charging and inequitably distributed geographically.

It is true that the Department was reluctant to increase its financial commitment to secondary education for building purposes and in this way recognized the private ownership of these institutions. This, however, is not to say that the Department lacked significant control over the system, it is rather saying that the Department in line with government policy during this period preferred to exercise its authority indirectly and in less financially demanding ways. This was accomplished very effectively through its Rules and Programmes for Secondary Schools which contained conditions for recognition of secondary schools as well as the programme of instruction which suffered no fundamental revision since 1924. The Department syllabuses and the Department controlled Intermediate and Leaving Certificate examinations effectively determined the scope and type of education in Irish secondary schools, *an education which remained severely classical and linguistic in orientation until very recent times* [15].

From the vantage point offered by the nineteen fifties and with the benefit of hindsight, looking back to the beginning of the new Irish State and retracing the course of educational history one can identify some encouraging developments in Irish education. The system of vocational education had been organized under statute by the 1930 Vocational Education Act. Local involvement was encouraged and statutorily provided for in the form of Vocational Education Committees.

Rating authorities were required to strike a rate to support vocational education. Central government funds as well as rates monies supported expansion. Many new schools were built especially in rural areas providing technical education as well as an alternativve secondary education at a nominal charge in its continuation education programme. The continuation education course of two years duration provided education in general subjects with a practical rather than an academic orientation. Technical education leading to trade and professional qualifications was reorganized under the Act and supported by the 1931 Apprenticeship Act which provided for the organization of specified trades. Thus the State was providing a form of non-elementary education for its children. This provision was augmented by a number of 'secondary tops', higher departments of national schools which were recognized for the purposes of providing academic secondary education, but because they were technically part of the primary school system and conducted by primary teachers were free except possibly for a small tuition fee. The vocational education system, however, suffered the same malady as the other education sectors in that it was based on the concept of the small rural school and this in turn contributed to the large number of small school units. The question of the economic viability of small school units had been problematic since the turn of the century and had been acknowledged as such by the government. But a policy of amalgamation in primary and secondary sectors could only proceed with the compliance, not always forthcoming, of the Catholic Church. The problem had reached major proportions by the late fifties, a fact confirmed with great authority by the <u>Investment in Education Report</u> in the early sixties [3].

Comfortably secure at the same vantage point and remote from the milieu of contemporaneous history an unfortunate pattern is evident in Irish education. Critically aware of the lack of coordination between the various education boards under the British administration in Ireland the Irish government persisted with a Department of Education which failed or lacked the desire and resources to effectively coordinate the various sectors of the educational system. Astonishingly the Council of Education reported in 1960 that no greater coordination between primary and secondary education was necessary than the free passage of pupils from one to the other [11]. There was no evident coordination between the curriculum in primary and secondary schools. Vocational schools operated independently of secondary schools and two-way access from one to the other was lacking. The universities for their part were autonomous institutes operating under charter and remained aloof from the school system. Few Irish families could afford the cost of university education even if possession of the Leaving Certificate guaranteed easy access to places. Demand for places grew after World War 11 and overcrowding became a problem at the National University. This forced the authorities to review entrance requirements which were subsequently raised. Increased demand for education at all levels, especially secondary and university *and an awakening to the economic realities of educational provision within the framework of the national economy was beginning to spur a comprehensive approach to education in Ireland.*

13. Economic Programming, the Government and Education

Economic targets were more important than educational objectives in the fifties, a time of depressed economy, high unemployment and emigration. The depression of the fifties gave way to a boom in the sixties, an economic upsurge with its basis in the government's First Programme for Economic Expansion which was laid before the Oireachtas in November 1958. For the first time an Irish government used economic programming as an instrument of policy to promote economic growth. The policy met with a large measure of success, thus creating a favourable climate for the introduction of the government's Second Programme for Economic Expansion in 1963 to cover the years 1964-70 inclusive. Experience with the First Programme showed that human factors such as education, training and skills as well as economic considerations had to be reckoned with. The Second Programme recognized explicitly the supportive role of education and training in the quest for increased production and the need for increased investment in that area. Such a realization prompted the government to commit itself to give special attention to 'human investment' such as education and training [20]. The Second Programme was followed by the Third Programme in 1969, a major readjustment in the national economic plan. The point of this digression into economic history is seen in the new trend in Irish education dating from the Second Programme; *a view that sees education as a whole and some sectors in particular, as being necessarily more responsive to the general economic needs of the country.*

14. Prosperity, Optimism and Educational Reform

New found prosperity and optimism and renewed interest in education contributed to an educational revolution in Ireland in the 1960's. The resolve of ministers for education to reform the system was strengthened by the OECD Report Investment in Education, a monumental study on Irish education published in 1965 [3]. This scientific study provided sound statistical evidence on which to base government policy in education. It signalled the beginning of a more determined drive to phase out small schools by consolidation and amalgamation. Inequitable participation by social class in secondary education was highlighted and the inadequate flow of pupils into secondary education was documented. The report was expected to serve as the basis for the formulation of a long-term policy for education and a Development Branch in the Department was set up to further that objective. But immediate action to remedy serious weaknesses in the system was initiated in May 1963 by Dr. Hillery, Minister for Education. He identified the absence of post-primary educational facilities in areas of the country and the conduct of secondary and vocational systems as distinct non-cooperative entities as the major structural weaknesses in post primary education in Ireland [21]. The aims of Dr. Hillery's plan were given in detail in the Second Programme for Economic Expansion and included the objectives of providing comprehensive post-primary education in previously unserviced areas, raising the status of vocational education to parity with secondary education and the provision of increased scholarship aid to enable pupils to avail of higher educational opportunities [20]. The government comprehensive schools would be designed to combine academic secondary and vocational courses in the junior cycle i.e. up to the Intermediate Certificate after which pupils would either transfer to other schools to complete the senior cycle leading to the Leaving Certificate or terminate their formal schooling. Senior cycle courses would be provided in Regional Technical Colleges and Secondary schools. The two-year day-course in

Vocational schools would be extended to three years and at the end of their three year course Vocational school pupils would be admitted to a Common Intermediate Certificate on the same basis as Secondary school pupils. A technical Schools' Leaving Certificate was envisaged, but never implemented, either as the terminal qualification for those pursuing education in the vocational system or entrance qualification for those wishing to pursue higher courses in Regional Technical Colleges and Colleges of Technology and in some University faculties. This was the beginning of a determined effort by the government *to break down barriers between vocational and secondary education.* The policy has been pursued and amplified and still exists as an active government aim today. State comprehensive schools were built during the following years at Shannon, Cootehill and Cararoe. By 1967 and the introduction of the 'Free Education Scheme' it became clear that a state-run system of comprehensive schools was un-necessary. Government policy of direct intervention in building and management was modified to one of seeking comprehensive educational provision by better utilization of existing secondary and vocational facilities. *Better provision through rationalization has been the touch-stone of all recent educational policy.* This policy achieved institutional form in the government's Community Schools, mergers of publicly owned Vocational schools (or schools to be) with private secondary schools (or schools to be).

More fundamental and of more enduring importance was the achievement of free education for all. The 'Free Education Scheme' proposed by the Minister for Education, Mr Donogh O'Malley, was accepted by the schools in 1967. Initially the Minister's scheme provided for free education up to the completion of the Intermediate Certificate course i.e.junior cycle in Vocational Schools, state-run comprehensives and Secondary Schools. This coincided with the government's aim to raise the school leaving age from fourteen to fifteen which in turn necessitated the provision of three years post-primary education for all free of charge. In fact when the scheme was implemented the government surpassed the initial proposals and introduced free education up to Leaving Certificate including free books, and free transport for all children more than three miles from the nearest post-primary school. Pupils, henceforth, would proceed to Leaving Certificate irrespective of their performance in the Intermediate Certificate Examination. Along with these measures the Department had encouraged greater participation in post-primary education by discontinuing its entrance requirement in September 1966 [22]. These developments in Irish education are all the more remarkable when viewed against a background of long standing government apathy towards education and latterly, the cautious and consciously slow movement towards equal educational opportunity for all.

Government momentum in education in the 1960s was primarily inspired and maintained by the desire for economic expansion. The OECD report <u>Investment in Education</u> was commissioned for the purpose of assessing the future educational requirements of the country if economic targets were to be realized [3]. The emphasis in the ensuing years was to adapt or modify education in Ireland so that an adequate supply of skilled manpower was available to support industrial activity. In these circumstances it was inevitable that the immediate effects of government policy were felt in vocational education, an area more responsive to government control and potentially more useful. This sector provided school-leavers with the kind of technical skills and practical background necessary for economic growth. The government's policy of the 'comprehensivization' of Irish education coincided with and became the vehicle for the type of restructuring of the education system *which was projected to yield maximum return for the citizens of the State both educationally and economically.* It was clearly recognized that the Vocational education system had an important role to play in the economic restructuring of the country. After Dr. Hillery's announcement on 20 May 1963 it was equally clear that the same sector had a vital role to play in the restructuring of education which was about to commence.

The Department of Education, in line with government policy, expanded its activities in vocational education. Many new schools were built and others extended demonstrating the Department's resolve to provide additional facilities in this State-controlled sector. Simultaneously action was taken calculated to upgrade the continuation course in Vocational schools. This course was extended by one year putting it on par with the junior cycle course in Secondary schools. A coordinated approach to Intermediate Certificate courses required a revision of the existing programme. The Common Intermediate Certificate programme was introduced in September 1966 allowing pupils to study for the Intermediate Certificate Examination irrespective of whether they attended Vocational or Secondary schools. Prior to then this examination was confined to secondary school pupils. Similarly the Day Group Certificate Examination previously confined to Vocational school pupils was opened to Secondary Schools. In 1969 this momentum was carried even further and in that year the Department allowed some Vocational schools to conduct senior cycle courses leading to the Leaving Certificate examination. *Thus an alternate avenue to higher education had been opened in the vocational education sector* and this gain was consolidated and ultimately expanded in the Regional Technical Colleges. These colleges were designed and projected to provide higher technological and commercial education on a regional basis [23]. Initially these colleges were to provide senior cycle courses for vocational school pupils so that all such pupils could complete their second level education in the vocational sector if they so wished. The first Regional Colleges opened their doors in 1969 [22]. Today the entire country is serviced by a network of nine regional colleges and two Colleges of Technology. The pattern of post-primary education today is increasingly one of *shared facilities between secondary and vocational schools enabling the provision of a comprehensive curriculum right up to Leaving Certificate for all pupils.*

State intervention in Vocational Education was not confined to continuation education. Renewed interest in technical education especially as this related to apprentices manifested itself, the underlying cause being as much a matter of economic progress as education. The need for tradesmen, skilled operatives, and technicians was evident and the projected shortfall in skilled personnel at all levels was highlighted in Investment in Education, (1965), and the report of the Steering Committee on Technical Education presented to the Minister for Education in April 1967. Higher technician education with a minimum entry requirement of the Leaving Certificate was provided in the newly constructed Regional Technical Colleges, the first of which opened in 1969. Apprentice education, essentially a second level activity, is carried on mainly in the Vocational schools and the Regional Technical Colleges at present and is generally well provided for, being controlled nationally by the statutory Industrial Training Authority (AnCo). This body has wide powers under the Industrial Training Act (1967) to make legally binding rules relating to all aspects of apprentice education and training. The Act charges the Authority with the obligation of [24]:

> specifying the minimum age at which a person may commence to be employed and rules in relation to the educational or other qualifications as to suitability to be possessed by persons entering the said employment as such apprentices.

However, a brief survey of apprentice education in Ireland since 1922 shows that this area was long neglected. This is not surprising in a country which lacked a heavy concentration of industrial activity as indeed Ireland did after partition. There was no organized system of apprentice education and training in Ireland in the period 1922-30 the prevailing practice being the 'closed-shop' system. The Vocational Education Act (1930) with its wide definition of technical education as [18]:

> education pertaining to trades, manufactures, commerce, and other industrial pursuits (including the occupations of girls and women connected with the household) and in subjects bearing thereon or relating thereto and includes education in science and art (including, in the county boroughs of Dublin and Cork, music) and also includes physical training.

allowed the Vocational Education Committees latitude in the provision of courses for apprentices. The government intervened directly in 1931 and passed the Apprenticeship Act, its first tentative efforts to organize apprentice education and training in independent Ireland. Under the Act the Minister for Industry and Commerce was empowered to declare a trade a 'designated trade'. In the event of a trade being so designated it came under the control of an ad hoc committee appointed by the Minister and empowered to determine the period of apprenticeship, minimum rate of wages and maximum weekly working hours for apprentices in that trade. The Act achieved some success and a few trades were designated and organized. The major defect in the Act was the nature of the committees' responsibility; it remained within the the discretion of the committee whether or not to make a rule requiring employers to train and instruct apprentices. The principle of voluntary cooperation between employers and trade unions implicit in the Act rendered it ineffectual. This Act remained in force until it was repealed by the Apprenticeship Act (1959).

The most significant developments during the intervening period were the Department of Education's revision of examinations in technical subjects in 1936, the provision of pre-employment training in Vocational schools and temporary courses to provide skilled operatives for new industries. Perhaps the most significant development was the provision of permanent training facilities for apprentices who were allowed to avail of technical education during normal working hours. The Apprenticeship Act of 1959 besides repealing the inadequate Act of 1931 provided for the establishment of An Cheard Chomhairle (National Apprenticeship Board) and statutory committees to regulate trades.

Under this Act the Board had power to require all employers to send their apprentices on training courses. In 1960 the Board set the minimum age for entry to apprenticeship as fifteen, the minimum educational qualification in each trade was determined to be the Day Group Certificate or Intermediate Certificate Examinations. The Board was empowered to make arrangements with Vocational Educational Committees for courses of instruction and the Board might compel employers to release apprentices for attendance at such courses. The Board insisted on regular practical and written examinations and stipulated that two at least - one midway and the other at the end of course - must be passed. Certificates were awarded to successful apprentices who passed the final examination. A number of statutory committees were set up under the Act which prescribed minimum educational requirements and training programmes for entrants [17]. The minimum age and educational requirements established by the Board became compulsory in September 1963. Difficulties with this Act led to the Industrial Training Act (1967) which repealed the Apprenticeship Act (1959). This Act provided for the setting up of An Chomhairle Oiliuna (Industrial Training Authority) which took over and expanded the functions of the National Apprenticeship Board [22]. All aspects of recruitment and training of apprentices is regulated under this Act and the Industrial Training Authority has emerged as an important body in its own right providing valuable service to the community.

The only significant modern innovation in secondary education since the period immediately following independence was the introduction of an oral Irish test as part of the Leaving Certificate examination in 1960. This is indicative of the government's attitude to secondary education and the general apathy shown towards education. The official position led to a situation in which the state refused to contribute towards building costs in the secondary school system. This in turn gave rise to a climate which promoted traditional grammar-school type subjects, a fact which is not surprising due to their relatively 'cost free' standing in terms of equipment and facilities. Happily, the expansionist mood of the 1960s was reflected in secondary education and changes made were fundamental and far-reaching. Dr. Hillery's programme for the 'comprehensivization' of second level education announced in 1963 had implications for secondary education, initially in terms of curriculum but later this policy would lead to a new role for secondary schools. Improvements in scholarship provision and a fundamentally different approach to the funding of scholarships was introduced in 1961. For the first time the State would bear a substantial proportion of costs directly. However, these changes insofar as they related to scholarships tenable in secondary schools were rendered unnecessary with the introduction of the Free Education Scheme in 1967. Unrestricted access to post-primary education was achieved finally when the remaining financial barriers were removed by providing free transport and free books. The cirriculum itself was subjected to many revisions beginning with new Leaving Certificate science courses in 1962 and followed by new mathematics syllabuses in 1964. The Hillary plan precipitated a revision of the Intermediate Certificate programme and a common programme was introduced in 1966. A committee appointed in 1967 to examine the Leaving Certificate course recommended change, but the changes were rejected by the universities and secondary schools. The notion of an Advanced Certificate at 18+ was dropped and the recommended grouping into five subject groups remains optional although promoted by the Department of Education. Revised courses for Leaving Certificate commenced in September 1969. Significantly the above committee was representative of the universities. The university involvement at this time was not unrelated to contemporary problems of entrance requirements to the universities. Through its entrance requirements the university exercised *considerable influence on the shape and content of the secondary curriculum.* This influence far from waning has indeed increased in recent years. The changes in matriculation announced by the National University requiring honours in at least one matriculation subject in Leaving Certificate from 1967 and honours in two matriculation subjects from the following year had repercussions on secondary education. The choice of subjects taught and to a large extent teaching methods used are dictated by university acceptance criteria which have been made increasingly rigorous of late, notably by the application of a 'points system' and specified extra requirements for some individual faculties. This influence contributed to the examinations bias in Irish secondary education and much recent effort has been devoted to the removal of this undesirable attribute. Efforts in this direction have been confined to the examinations themselves, the passing criteria and the award of certificates. A grading system was introduced into the marking of Intermediate and Leaving Certificate examinations in 1969 abolishing the honours/pass classification [22]. The whole question of the desirability of external examinations was examined by the committee appointed in 1970 by the Minister for Education 'to evaluate the present form and function of the Intermediate Certificate Examination and to advise on new types of public examinations'. The committee recommended the abolition of the Intermediate Certificate examination which 'should give way to an on-going service of school-based assessment, supported by external moderation and nationally normed objective tests' [25]. No action has been taken by the Department of Education since the Minister received the report in September 1974. The evident move away from examinations and towards school-based assessment though slow, allied to other developments such as government policy of comprehensivization of second level education and reorganization of third level education augurs well for the future of second-level education in Ireland.

15. A Brief Summary of Important Developments in Irish Education in the 1960's

The 1960's spanned a decade of great change in the educational arrangements in the post-primary sector which eclipsed, but did not blot out completely, activity in university and higher education generally. The Minister for Education, Dr P J Hillery, set in motion an investigation into higher education, by far the most important development in higher education since the founding of the State. The government appointed Commission on Higher Education reported in 1967 after six years of work. It is fair to say that the Commission's report has stamped its imprint on matters relating to higher education since publication. The report was followed by the appointment of the Higher Education Authority on an ad hoc basis pending the government bill, the Higher Education Authority Act (1971) making specific statutory provision for the establishment of an Higher Education Authority. This Authority was set up in 1972 with wide powers in higher education especially in the area of finance and coordination of higher education services [26]. All monies would henceforth be channelled to the various institutions through the Authority. By so doing the government served notice that its intention was to coordinate all higher education and to rationalize provision wherever possible. The emergence of higher non-university technological education in the form of Regional Technical Colleges and the National Institute for Higher Education, and important changes in teacher education have taxed the coordinating function of all in education including the Higher Education Authority. For a time it looked as though a state-sponsored binary system of higher education was evolving with the technological sector under the aegis of the newly appointed National Council for Educational Awards with powers to validate certificate, diploma and degree courses in that sector. An academic university system would remain, although under pressure to be more responsive to the needs of the society which supports it. Various institutional arrangements in higher education were mooted notably the Commission's report (1967), the Minister for Education, Mr Donogh O'Malley's plan for university education in Dublin (1967) and the governments proposals for higher education published in December 1974. In any case, government policy in third level education will be determined with some finality in impending legislation. The Higher Education Authority is presently considering heads of bills drawn up by the Minister's working party. If the previous decade is remembered for fundamental changes in the post-primary sector then the 1970s will endure in memory as a decade of revolutionary changes in higher education.

It would appear that the government in its concern for educational reform has inverted the process. Avowedly promoting primary education as the foundation on which the edifice of second and third level education is built, efforts have been directed towards reforming post-primary and then third level education without prior or concomitant progress in the primary sector. This preoccupation with second and third level education is not unrelated to economic policy and is directly related to the governments determination to provide a comprehensive system of education and to appropriate for itself what it considers to be a sufficient measure of control. It could be argued that the primary sector was not neglected and that the introduction of the new child-centred curriculum in 1969 was sufficient. This was preceded in 1963 by a school library scheme which was designed to provide the nucleus of a reference library in each primary school to support teacher activities. Later the stricture of the compulsory Primary Certificate Examination was removed by the abolition of the examination in 1967. But these laudable efforts are already severely constrained within the existing institutional arrangements in the primary sector. Difficulties still exist in the matter of coordinating curricula in primary and post-primary schools. The examination oriented curriculum and school organization of post-primary schools is in complete contrast to the child-centred approach experienced by children in primary schools, so much so that upon transferring the pupil finds himself in an alien school environment which inevitably hinders his subsequent development. The recent Intermediate Certificate Examination Report on the form and function of the Intermediate Certificate Examination proposes a system of school based assessment to replace the current system of externally moderated Intermediate Certificate Examination at the end of the Junior cycle [25]. This augurs well for pupils transferring from primary to post-primary schools because the junior cycle programme could conceivably take on a genuinely child-centred format and effect maximum coordination between the primary and post-primary curriculum.

The government has yet to act on these proposals, meanwhile the difficulties remain and if the various teachers' unions are to be believed, are being accentuated with the passage of time.

At the time of writing it is fair to say that the entire educational system in Ireland is in a state of flux. On the evidence available definite patterns seem to be emerging and some of these have been alluded to already, however only hindsight can confirm the accuracy of these predictions. What is certain and readily discernible at present is that all aspects of education in Ireland have been stamped though belatedly with a truly Irish seal and the Department of Education with its Minister have emerged from decades of relative obscurity to occupy a central position in the affairs of the country.

CHAPTER III

THE IRISH EDUCATION SYSTEM II : AN OVERVIEW

The Constitution of Ireland guarantees many fundamental rights; important among them is the right of every citizen to free primary education. The fundamental principles of Irish education are contained in Articles 42 and 44 of the Constitution [27]:

Article 42

1. The State acknowledges that the primary and natural educator of the child is the Family and guarantees to respect the inalienable right and duty of parents to provide, according to their means, for the religious and moral, intellectual, physical and social education of their children.

2. Parents shall be free to provide this education in their homes or in private schools or in schools recognized or established by the State.

3. 1° The State shall not oblige parents in violation of their conscience and lawful preference to send their children to schools established by the State, or to any particular type of school designated by the State.

   2° The State shall, however, as guardian of the common good, require in view of actual conditions that the children receive a certain minimum education, moral, intellectual and social.

4. The State shall provide for free primary education and shall endeavour to supplement and give reasonable aid to private and corporate educational initiative, and, when the public good requires it, provide other educational facilities or institutions with due regard, however, for the rights of parents, especially in the matter of religious and moral formation.

5. In exceptional cases, where the parents for physical or moral reasons fail in their duty towards their children the State as guardian of the common good, by appropriate means shall endeavour to supply the place of the parents but always with due regard for the natural and imprescriptible rights of the child.

Article 44.2.4°

> Legislation providing State aid for schools shall not discriminate between schools under the management of different religious denominations, nor be such as to affect prejudicially the right of any child to attend a school receiving public money without attending religious instruction at that school.

The State has introduced an element of compulsion in the interests of the common good. Every child between the ages of 6-14 years must be educated in an acceptable manner as defined in the School Attendance Act (1926) and consonant with the Constitution. The minimum school-leaving age was raised to 15 years in 1972 by order of the Minister under provision of the same Act. While legal provisions such as these and others are important in shaping education, educational provision in a country is greatly influenced by other factors such as the prevailing political ideology and the economy. It is relevant in this respect to point out that the Irish State has been moving steadily towards the Welfare State. Contemporaneous developments in education certainly show signs of prejudicial influence if not direct causality [28]. The State moved progressively from a denial of responsibility in secondary education, a position cherished from the founding of the State until the late fifties, to active promotion of comprehensivization of post-primary education and the assumption of the concomitant financial burden. Free primary education has been augmented by free post-primary education for all. Selection for post-primary education has been discontinued with a view to increasing participation in second-level education. It is fair to say that many of these steps were taken with the demands of the economy in mind. Many developments in education since Investment in Education fit easily into a picture of a State pursuing an efficient educational system and national economic growth.

These opening remarks taken in conjunction with the residue of the historical background already provided should serve as an appropriate introduction to the general survey which follows. It should be pointed out, however, that this survey only touches on teacher education, an aspect which has been singled out for special attention in a later chapter because of its central role in this thesis.

1. Descriptive Terms: Origins and Explanations

The Irish education system has many structural components, each with its own peculiarities, due in the main to different historical circumstances of origin and subsequent development. What rationalization does exist is due to the efforts of the Irish government to coordinate the various branches to ensure the existence of an educational route from primary through secondary and on to higher education. The Irish government has not been in a position at any time since the founding of the State to effect a complete rationalization and integration of the disparate elements. Even if it had the will to do so, the State lacked the material resources. There is no education act to regulate the system as a whole on agreed principles giving positive direction to the educational endeavour of the nation. *There is no single articulated statutory system encompassing all or most of the formal educational services.* The Government until very recently confined its activities in education to supervision and administration and this despite the fact that the government exercised an effective control over education through its Minister for Education and his department. The nature and extent of this control will be outlined in a later section.

An early introduction to the ordinary terms in use in Ireland to describe the education system, it is hoped, will ease the burden on the reader. Viewing the education system as a whole it is the practice to speak of levels, viz. first, second and third level education. This practice is recent in origin and owes much to its inherent administrative convenience. Third level education is the term used to describe the totality of higher education courses, university and non-university. Until the general widespread availability in Ireland of higher non-university courses - a recent development- higher education was synonymous with university education. Second level education is the term used to describe the multiplicity of post-primary educational services offered in Secondary, Vocational, Comprehensive and Community Schools, including apprentice courses in the Vocational sector. Post-elementary schooling is variously described as post-primary, secondary or second level. The designation 'secondary' as used in secondary education is not unambiguous in the Irish context. The traditional interpretation of secondary education coincides with the view that sees it as a grammar-school type education obtained in a privately owned Secondary School, and is therefore heir to the Intermediate education of the nineteenth century. Intermediate education was officially renamed secondary education in the Ministers and Secretaries Act (1924). Secondary education was distinct from technical education and remained so until the 1960s. The system of technical schools was consolidated and expanded under the Vocational Education Act (1930) which introduced and defined a new element called 'continuation education'. Vocational education was a term coined in the Act as a generic term covering technical and continuation education which was offered in Vocational Schools. The deliberate blurring of the boundaries between traditional secondary and vocational education, a policy begun in the 1960s with the introduction of comprehensive schools, is designed to bring about a situation in Irish education which might be appropriately described as secondary, as OECD [29] uses that term i.e. secondary education seen as general or technical. In Ireland first level education is the exclusive preserve of primary or national schools which cater for infants 4-6 years and children in the first six years of compuslory schooling. The designation 'national school' survives today in popular and official usage despite a change in name to primary school introduced in the 1924 Act. The education system, therefore, is amenable to analysis by level, the first and second taken together comprising the Irish School System.

2. Legislative Basis

The administration of education, insofar as education is the responsibility of the State, is vested in the Department of Education. This department is headed by a Minister for Education who is a member of the Government and responsible to Dail Eireann for the conduct of his department. The Department exercises jurisdiction over primary, post-primary and higher education but in varying degrees. The source of Department of Education authority is ultimately the Oireachtas but the nature and limits of this authority and the peculiar arrangements for its exercise are worth investigating briefly in the interests of a better understanding of current practices in Irish education. The Irish education system is *a non-statutory system but is in general State-aided.* The State assists other bodies to operate schools being unwilling as a matter of Government policy to undertake the enlarged responsibility except in rare instances. The State discharges its constitutional obligation to provide free primary education for all children, through denominational primary schools owned and managed by clerics. Educational policy insofar as it exists and is promoted nationally by the Minister for Education and his department must be realized generally in and through schools at all levels owned and/or managed by bodies other than the State. It is prudent and relevant in such circumstances to identify specific controlling instruments, if they exist.

The legal basis of the education system is not easy to establish complicated as it is by historical circumstances and the particular arrangements for the transition of power from the British Administration to an Irish government after independence. The various powers which the Minister for Education exercises today derive in many cases from powers originally conferred on the education boards set up in the nineteenth century and subsumed in the Minister's office by virtue of certain legal provisions enacted during the transition period. Statutory instruments some predating the modern independent State and others enacted since it was established have an important bearing. The continued relevance of Acts pre-dating the modern Irish State is due to special arrangements made in the transition period and subsequently. The Constitution of Ireland enacted by the people in 1937 is the basic law of the State. This instrument supplanted the Irish Free State Constition of 1922 which contained provisions (Article 73) by virtue of which laws actually in force when the Constitution came into operation remained in force to the extent that they were consistent with the Constitution [30]. The Constitution of 1937 contains similar provisions. However such arrangements necessitated a special Act known as the Adaptation of Enactments Act (1922) to enable Acts to remain in force by allowing interpretation and adaptation consistent with constitutional and other changes which had taken place. This applied equally to all orders and regulations made under the Acts in question. The new State vested its powers in education in the Department of Education and transferred them to the Minister for Education by virtue of certain provisions in the Adaptation of Enactments Act (1922) and the Ministers and Secretaries Act (1924). The minister accordingly gained power over the existing education boards which were subsequently abolished, their powers and functions having been concentrated in the Department of Education. The Department as it exists today dates from this period, specifically from the Ministers and Secretaries Act (1924) which entrusted the fledgeling department with responsibility for the administration of various educational services including national (primary), intermediate (secondary) and technical education. It should be noted that agricultural education was specifically excluded from the administrative sphere of the Department of Education, falling instead to the Department of Agriculture where it remains today. There it has developed along essentially independent lines and is for that reason consciously excluded from this survey of the education system.

The legal basis of the Minister's power over primary education has been indicated above but in practice the exercise of this power follows traditional procedures. The national system of education continues today under the Department of Education and is regulated by the <u>Rules for National Schools under the Department of Education</u> [31]. These rules derive from Stanley's letter to the original Board of National Education Commissioners in 1831. The rules which were non-statutory in nature were issued by Stanley on behalf of the Lord Lieutenant who retained the sole right to alter them, thereby preserving the Lord Lieutenant's prerogatives in elementary education and his accountability. The Minister for Education has for all intents and purposes assumed the functions of the Lord Lieutenant in these respects. He, therefore, administers primary education in accordance with a set of inherited rules which he may change at any time on his own volition and when necessary with the concurrence of the Minister for Finance [31]. It is not surprising that the system today is substantially the same in administration and organization as that which existed in the late nineteenth century. The important differences are (1) the Department of Education, unlike the Lord Lieutenant and his commissioners, explicitly and unreservedly acknowledges and endorses the denominational character of primary education in Ireland (2) the system is now administered by a Government Minister directly responsible to the Irish Parliament and is therefore ultimately amenable to the will of the Irish people through the democratic process.

The administration of post-primary education insofar as the State is concerned is regulated in many different ways. Intermediate education renamed secondary education in the 1924 Act, is subject to rules made by the Minister in pursuance and by virtue of the Intermediate Education (Ireland) Acts, 1878 to 1924 [32]. These rules are published annually by the Department of Education in Rules and Programme for Secondary Schools which is an important regulatory instrument in secondary education. Compliance with these regulations and others to be found elsewhere is a necessary prerequisite for State aid. Significantly the modern system of secondary education is based on reforms introduced by native government in the Intermediate Education (Amendment) Act (1924). The origins of other regulating devices are to be found in the relevant Intermediate Education Acts. Inspection was introduced following provisions in the Intermediate Education Act (1900) and an Inspection Grant was payable under provisions in the Intermediate Education Act (1913). The latter form of State aid was a significant departure from the 'payment by results system' on which intermediate education was based, to the exclusion of all other forms of aid. The abolition of the 'payment by results system' followed in 1924 and it was replaced by a system of capitation grants. In 1914 statutory provision for a teachers' Registration Council was made in the Intermediate Education Act (1914). The Registration Council was constituted in 1916 and the register is effective from 31 July 1918. The Registration Council is still extant and the register is administered in accordance with the Regulations for the Register of the Intermediate School Teachers published occasionally by the Council. It was last published in 1967 [33]. The same 1914 Act provided for the payment of the Teachers' Salary Grant. This was continued until 1920-21 when an Interim Grant was made available directly to secondary teachers in the Irish Free State who satisfied certain conditions. An Incremental Salary Grant for Secondary Teachers was introduced in 1925 replacing the Interim Grant [11]. The Department of Education continues to pay incremental salary to secondary teachers according to the Rules for the Payment of Incremental Salary Grant to Secondary Teachers [34]. All grants to secondary schools except building grants introduced after 1964 are regulated by the Rules for the Payments of Grants to Secondary Schools published periodically by the Department of Education [35]. The Department proceeds in secondary education with due regard for the State's obligations and policy in education, respecting long standing conventions and traditions and scrupulously observing the regulations contained in the above named publications.

Vocational education is an invention of the modern Irish State and it is regulated by statute.. All development in vocational education derives from the Vocational Education Act (1930) [18]. The system is controlled at local level by statutory education committees elected by the public representatives of the local rating authorities. These committees generally perform the customary functions of an educational authority in the discharge of their statutory responsibilities. Each committee has a permanent chief executive officer who acts as secretary/accountant and otherwise functions as a director of education within the rating authority's administrative area [3]. Each committee's educational programme and expenditure is subject to the approval of the Minister for Education. The Minister approves all teacher appointments in accordance with basic qualifications prescribed by him in Memorandum V.7 of the Department of Education now currently under review. The Minister on occasion has found it necessary to elaborate on definitions contained in the 1930 Act in the interests of providing direction in that area of the educational activity. For example, Memorandum V.40 of the Department of Education issued in 1942 contains the definitive statement on continuation education in Ireland and is generally held to be the charter of continuation education. It is clear therefore that the vocational system is a State system. So also are the comprehensive schools State schools. Built after 1963 these shcools were wholly financed by the State and are completely controlled by the Department of Education. Community schools on the other hand still under the aegis of the Department of Education will be controlled in accordance with a deed of trust executed by the interested parties. To date no such deeds have been signed and the conditions contained in draft copies appear to be meeting opposition from teacher and religious bodies alike although for different reasons. Vocational education excepted obstacles to the type of cooperation implied in the Government's policy of comprehensivization of school facilities were less than statutory. The type of cooperative effort envisaged for the vocational education committees required amending legislation. The Vocational Education (Amendment) Act (1970) [36] provided the necessary scope for the vocational education committees to broaden their statutory activities *through formal cooperation with other bodies*.

The country is served by two university institutions, Trinity College, the only college of the University of Dublin and The National University of Ireland, a federation of three constituent colleges located in Dublin, Cork and Galway. Each university *operates autonomously under charter*, Trinity College dating from 1591 and the National University from the Irish Universities Act (1908). Each institution receives substantial financial aid from the State which until recently has been channelled through the Department of Education. Efforts to rationalize the development of third level education generally including university education have led to the establishment of the Higher Education Authority, a statutory body charged with responsibility for considering new courses and plans and controlling expenditure in third level education [26]. The creation of such a body was timely, and motivated in part by the spectacular growth of technological education in non-university institutions during the past decade. Since 1969 the Department of Education has built nine regional technical colleges, a National Institute for Higher Education in Limerick, a second in Dublin is planned and established the National Council for Educational Awards (NCEA) a validating body for awards in the techno/commercial area. The regional colleges are now firmly absorbed into the vocational sector and controlled ultimately under the 1930 Act. This is also true of the Dublin Colleges of Technology, Kevin Street and Bolton Street, and many other vocational education colleges in Dublin, Cork and Limerick. The National Institute for Higher Education Limerick, not yet constituted as a statutory body is administered by a Board of Governors for the Minister for Education. All teacher training institutions with one exception are affiliated with university colleges. These institutions with one exception are private, State-aided and ecclesiastically controlled. Thomond College of Education subsumed the National College of Physical Education and is charged with responsibility for the education and training of teachers in Physical Education, Metalwork, Woodwork, Rural Science and other technical subjects for second level schools. The College is administered by a Board of Governors for the Minister for Education. The ideal of an all graduate teaching profession has inspired the links between the colleges of education and the universities. And all those who complete teacher training courses receive university degrees with the exception of Thomond College whose graduates are awarded NCEA degrees. Its degree awarding powers having been restored in 1977 the National Council for Educational Awards will henceforth validate all degree awards in the non-university sector as well as diplomas and certificates. New legislation is imminent and these arrangements are expected to receive the force of law in the near future. The National College of Art and Design, Dublin, is controlled under provisions of the National College of Art and Design Act (1971) [37].

3. The Church-State Monopoly in Irish Education

That a unique partnership exists between Church and State in Irish education is undeniable. An enquiry, therefore, into the basis and nature of this partnership must shed light on the structure of the Irish school system and the nature of the controlling interests. Where does control lie? Posed in such bald terms the question is much too provocative for either parties and besides it shows a certain disrespect for the cordial co-existence worked out over the years. Much has been done on both sides to preserve the public image of happy co-existence. However, local high-tension peaks are inevitable in Church-State relations in respect of education, as for example the one provoked by the then Assistant Secretary of the Department of Education, Mr S O'Connor [38] when he stated bluntly that "No one wants to push the religious out of education; that would be disastrous, in my opinion. But I want them in it as partners, not always as masters". By implication then the Church is seen as the senior partner and so it remains today. Whyte [39] an expert on Church-State relations in Ireland has this to say:

> Over most of the period since independence, the remarkable feature of educational policy in Ireland has been the reluctance of the State to touch on the entrenched positions of the Church. This is not because the Church's claims have been moderate: *on the contrary it has carved out for itself a more extensive control over education in Ireland than in any other country in the world.* It is because the Church has insisted on its claims with such force that the State has been extremely cautious in entering its domain.
>
> [my italics]

Cognizant of the sensibilities of both partners the question of control might better be approached from a different angle and framed as follows: how is education in Ireland controlled? This perspective eliminates visions, easily conjured up, of churchmen, politicans and civil servants busy at work protecting the <u>status quo</u> in Irish education. The <u>status quo</u> is enshrined in a new Church-State convention: the State undertakes for its part to perpetuate the Irish school system in particular, and education generally on denominational lines; in return the Church acquiesces in extreme State-centralization of the school system. In practice this means that State innovation in education is Church approved. It is not so much that the State consults the Hierarchy prior to determining policy, although sometimes it does, but rather the State proceeds in education in the absence of Church opposition. The outcome is scarcely ever in doubt, as Akenson [15] so aptly put it "if the Catholic authorities really cared about a given issue or set of institutions, they had sufficient influence and power to have their own way". Further the respective legal prerogatives of each party are not sufficient to sustain such an accommodation, an accommodation which requires goodwill and mutual consent.

A more penetrating analysis of Church-State relations in respect of education is possible if the ultimate source of each party's authority is established. The exercise and growth of power is influenced by, among other things, historical and local circumstances, and geographic and demographic factors. There is no denying the source of the Church's authority in education, it is God. The Church's doctrinal position is clear, the rights of Church and family in education are prior to the State's and inviolable. In practice the Church's power in education is directly related to the fact that the Church subsumes the rights of parents in education. Acting on their behalf and always with their support the Catholic Church in Ireland safeguards its doctrinal position. In important issues such as the education of the faithful the Church brings to bear all its institutional power made remarkable in the Irish context by the huge proportion of Catholics in the population. The privileges conferred by ownership of schools and a hundred years of tradition in education are not insignificant in this regard. Never has the Church failed to secure its position and Church rights and prerogatives have always been preserved to date in Irish education.

The principal partners in the Irish educational enterprise are the State and the institutional Catholic Church in Ireland. In one way or another all schools reflect this partnership in their government either overtly or otherwise. It is not surprising that the Roman Catholic view of education prevails in a country where the overwhelming majority of people profess Catholicism. It is noteworthy, however, to find such a view confirmed in the basic law of the State i.e. the Constitution, as is the case with Ireland. The orthodox Catholic position on education is supported and promoted by the Catholic Hierarchy in Ireland namely [40]:

> that education is the business of the church and of the family, institutions which are prior to the state and inviolable, and that the religious spirit must permeate instruction in all subjects. Without religion there can be no true education.

The State for its part finds little difficulty in reconciling the Church's interests in education and its own. Again this should not be surprising when the majority of government ministers, deputies and adults are devout Catholics thus perpetuating the circle of Church influence in education. Statements corroborating this view can be found in the Council of Education reports as for example [7]:

> the school exists to assist and supplement the work of parents in the rearing of their children. Their first duty is to train their children in the fear and love of God. That duty becomes the first purpose of the primary school. It is fulfilled by the school through the religious and moral training of the child, through the teaching of good habits, through his instruction in duties of citizenship and in his obligations to his parents and to the community - in short, through all that tends to the formation of a person of character strong in his desire to fulfil the end of his creation.

The same Council has this to say in its report on secondary education [11]:

> Our schools are the heirs of a great tradition and it is universally recognised that their purpose is in short, to prepare their pupils to be God-fearing and responsible citizens.

Irish schools include religious education and moral training on religious premises in the curricula as a matter of course. Provision is made in the timetable for religious instruction usually not less than three hours per week. Far from conflicting with the wish of parents, this may be seen as a response to their general wish. However, the Church and the State respect a conscience clause permitting parents to remove their children from lessons on religion. This latter arrangement facilitates the State in the discharge of its constitutional obligations in education in and through denominational schools without doing violence to the fundamental rights of its citizens. The major distinguishing characteristic of Irish education is therefore *its extreme denominationalism* an attribute protected and preserved by Church and State. This reflects the influence of the Catholic Church in Irish education, a determining influence which has been strengthened over the decades of the last hundred years. A politically astute Catholic Hierarchy safeguarded her vested interests, especially during the last century by wielding her institutional power. Conventions governing Church-State relations in the latter half of the nineteenth century existed, the most important being that the State would respect the Church's vested interests in the area of publicly financed education in return for which the Church undertook to use her influence to curb violent opposition to the State [41].
An accommodation evolved during the last century and referred to as the

'Managerial System' allows churchmen as patrons, owners and managers to control the majority of primary schools in Ireland. The power to hire and dismiss teachers resides in the manager who is invariably the parish priest appointed by his bishop acting as school patron. The state for its part provides aid in the form of payment of teachers salaries in full, and generous building grants usually not less than two-thirds of costs. Provision of school site and the other one third of costs is the responsibility of the manager. In practice the latter condition is relaxed with the state assuming the total cost of building the school.

The Irish State acts on behalf of the Irish people in education but state involvement must be consonant with the basic law of the State. The Constitution of Ireland enacted by the people guarantees the Church's rights in education implicity and circumscribes the power of the State. The nature and extent of legal control of education has been examined earlier but in a country where Church and State are in harmony it is the practice rather than the law that is more important. In practice the State exercises an effective control over education generally and the school system in particular. Control is extremely centralized and vested in the Department of Education. *Educational centrality ranks with denominationalism as a major distinguishing characteristic of the Irish system* [42]. This centrality is attributable to State supervision and administration and is self-perpetuating. In this context supervision refers to control of teaching while administration means control of the mechanism necessary to bring teacher and class together in the classroom [43]. Supervision by the State is well-established in Ireland and dates from the system of national education. Then, as now, it was carried out by a careful control of curricula, text-books and the training of teachers.

The state presently determines the curriculum in primary and post-primary schools and in some instances prescribes text-books and the amount of time allocated to subjects. Extern examinations set and marked by the central authority have proved to be highly significant supervisory instruments in post-primary education. Supervision is reinforced by the Department's corps of inspectors, each sector having its own inspectors. The Department of Education directly influences teacher training for the primary sector and only teachers recognized by the Minister for Education receive incremental salary in the post-primary sector. Administration is scarcely less centralized as evidenced by the prevailing circumstances. Nowhere has any real delegation occurred. At first sight the vocational system with its local education committees appears to be an exception. However, the vocational education committees' powers in education are strictly controlled by the Minister by *a process of auditing the validity of decisions as well as expenditure.* In practice these committees act more like local agents of the Department of Education than independent education authorities [42]. Primary education is effectively controlled by making the availability of essential finances dependent upon the adherence to a strict set of rules. A similar tactic is used to good effect in the private post-primary sector where despite private ownership schools follow centrally devised courses and examinations and employ centrally certificated teachers. School management boards in comprehensive and community schools bear the marks of centrality and will never function autonomously. In such circumstances State influence in education is undeniably great.

The Church's position in secondary education has never been seriously threatened by the State. From the beginning private ownership and the denominational character of secondary schools was recognized. Management of secondary schools is dominated by religious, the vast majority of secondary schools being conducted under the aegis of religious teaching orders. The inflow of public monies into the system firstly under the heading of building grants and later in return for participation in the Free Education Scheme has not been accompanied by increased State control. In spite of financial problems and a severe reduction in the number of religious teaching personnel occurring in a time of great expansions in post-primary education and magnified by it there has been no diminution of the Church's influence in education, if anything it has been enhanced. School managers are still appointed by the controlling religious orders from among their own ranks, lay principals being very much the exception in Irish secondary schools. The proposed boards of management for these schools as offered by the Conference of Major Religious Superiors [44] guarantees the principle of religious control by reserving to the Trustees the right to appoint six of the ten member board and the principal. Recently the proposed teacher representation has been raised from one to two elected members. Debate is continuing between interested parties.

The move towards *management committees* is a feature common to all sectors of the school system but democratization is more apparent than real. In all cases Church prerogatives are preserved and denominational education guaranteed. This is so even in the new post-primary institutions, State conceived and sponsored, namely the comprehensive and community schools where control has been delivered to denominational interests. These original Hillery comprehensives were run by three-man management committees representative of the local vocational education committee, local Catholic religious authorities and the Department of Education. This arrangement was worked out in consultation with the Catholic Hierarchy, the only other body consulted by the Minister at the time [21]. A shift in policy saw the Department providing comprehensive facilities by grouping together existing institutions to form comprehensive schools [45]. Management was shared by the local vocational education committee and representatives of the other institutions in the merger usually Catholic secondary schools. The management structure has led to a colonization of comprehensive schools by denominational interests and the spectre of Catholic and Protestant comprehensives. This could only happen in an atmosphere of active and favourable State intervention. Indeed denominational control is implicit in Department of Education plans for the comprehensivization of post-primary education. Current policy [46] is the implementation of comprehensive education through a network of community schools. Parents' views will be minimally represented on the management boards of these community schools whose composition reflects the community interests. The six-man boards will comprise two representatives of the merged secondary schools, and two parents. Significantly in all existing and newly devised management structures teachers and parents as interested parties have scarcely been recognized and only minimally represented. In such circumstances Church and State pay lip service to the principle of community involvement in education and deny teachers as a body professional status; neither parents nor teachers are blameless in this.

The State system of vocational schools was established as a non-denominational system under lay control. Vocational schools within borough, urban and county areas are collectively managed by the statutory vocational education committee for the administrative area. These fourteen-man committees are selected by the local rating authority; not more than eight may be members of the rating authority. Individual schools are directly managed by a principal appointed by the committee. Vocational schools are only an apparent exception to denominational education in Ireland. Church influence on vocational education derives in part from a parental attitude which invariably defers to Catholic clerical authority in educational matters and is reinforced by the high instance of clerical chairmen of local vocational education committees over the years [15]. The system is denominational in practice. Religious instruction is a time-tabled activity controlled by the bishop through his representative in the school. This practice was confirmed and indeed advocated by the Department of Education [47] in its memorandum on continuation education.

The Church-State partnership in Irish education effectively monopolizes control. It is significant but not surprising in view of circumstances that parents and teacher have been denied an effective voice in educational matters, a fact alluded to by a Department of Education official [48] as recently as 1971. The introduction of management boards into primary education is a small step in the right direction but as presently constituted control remains where it always has been. Similarly the management boards in post-primary schools are designed less out of real conviction for rights of parents and teachers than the need to maintain the <u>status quo</u> in education. The attitude of the Church is simple, parents rights in education are subsumed in the Church thereby eliminating the need for a separate parental lobby. The State agrees with this state of affairs since it is generally easier to deal with one interest group viz. the Church than two, and besides could parents possibly object to whatever

Church and State had determined, in the children's best interests, for the education of their children? Educational arguments in favour of parental involvement in schools have been less than enthusiastically received by Church and State in Ireland. It seems that Church and State in Ireland bow only to the inevitable and then long after everyone else. That parents did not object in the past hardly provides a solid basis for a continuance of this situation in the future. There is little justice in efforts no matter how well-intentioned they are, which deny parents an effective voice in the education of their children. Nor is it good sense to persist in denying teachers an effective role in decision-making. It is difficult to overcome an attitude reinforced by years of practice which reduced teachers to the status of hirelings. The Church has not been generous in its treatment of lay teachers. Consequently much effort by teachers has been directed towards securing basic rights such as living wage, security of tenure, pensions and the like. Teachers have not fared better under the Department of Education. It is hardly necessary to add that the teaching profession as a result has been retarded in its efforts to attain true professional status, a status not yet fully accorded. Other factors contribute to the overall weakness of the teaching profession. Primary and post-primary teachers are recruited from different educational backgrounds and mobility from primary to post-primary schools and vice versa, though possible, is not promoted. This leads to a situation where there is no representative professional body capable of promoting the interests of teachers as a whole. School teachers in Ireland are represented by three different unions, the Irish National Teachers Organization(INTO), the Association of Secondary Teachers of Ireland (ASTI), and the Teachers Union of Ireland (TUI), the latter representing teachers in the vocational sector.

The sectional interests of these unions contribute little to a unified teachers' voice in education. Encouraging signs have been evident very recently. A federation of the ASTI and the TUI has been approved in principle at the 1977 annual congresses. This is a welcome sign of solidarity and cohesion among teachers. Teachers are represented sectionally on the proposed Teachers Registration Council [49] a new statutory body projected to replace the Teachers Registration Council and regulate the teaching profession as a whole. Nevertheless, there is little doubt that the Church-State partnership will continue to determine the contours of Irish education but equally certain is the fact that the aspirations of parents and teachers will have to be accommodated. The challenge therefore is to accommodate the legitimate aspirations of Church, State, parents and teachers within the existing Church-State convention while doing justice to the pupils because Irish education is unlikely to shed its denominational aspect or centrality in the foreseeable future.

4. Finance

The Irish education system is in general State-aided. The State meets the bulk of educational expenditure from central funds raised through general taxation. The distribution of funds to the various sectors is in accord with established practices controlled by regulations which have been detailed elsewhere in this study. A very small number of private primary schools exist and are non-aided relying entirely on fees and other sources of revenue. Recognized primary schools receive State aid under three main headings (1) teachers salaries and pensions are paid in full by the Department of Education, (2) building grants, (3) capitation grant to cover general operating expenses such as maintenance, heating, etc. The State insists on a local contribution towards costs in primary education.

A variable contribution, nominally two-thirds of building costs, but usually 10 per cent is accepted, must be met from local resources. One-quarter of operating costs is likewise the responsibility of the local community. Other grants are available mainly for school requisites and equipment. School principals administer the grant for the provision of school books for necessitous pupils. Grants for provision of libraries in national schools are paid to the Local Authority who administer the scheme. In addition, the Department of Education incurs significant financial liabilities for a free transport service for children between the ages of 4 and 14 years who live at least three miles from the nearest national school [50]. Not surprisingly teachers' salaries and pensions constitute the principal item of recurrent expenditure. Salaries are paid directly to teachers in ordinary national schools and classification schools by the Department of Education. In some 140 (1974) convent and monastery national schools the religious community receives an amount in lieu of salaries based on the number of pupils in attendance i.e. a capitation grant [51]. Other convent and monastery schools 463 (1974) in all, officially styled classification schools differ from capitation schools in that religious receive personal salary. Members of religious orders in capitation schools do not qualify for teachers' pensions [52]. Rates of scale salary and allowances for all school teachers are negotiated through the appropriate Concilliation and Arbitration machinery but always with reference to a common basic scale and latterly within the terms of national wage agreements. It is obvious from these remarks that primary education is financed in such a way as to be available free of direct charge for all children.

Prior to the 1960's the State's financial commitments in post-primary education were relatively conservative. After the launching of the free education scheme in 1967 the State progressively assumed more of the financial obligations entailed. Currently the bulk of expenditure on post-primary education is met by the State. The complexities of State involvement in the financing of post-primary education are difficult to unravel. The problem is minimized if expenditure is treated under suitable headings. The principal items of expenditure are teachers' salaries, current expenditure and capital costs. It is proposed therefore to examine the State's commitment in the three categories across the whole spectrum of post-primary education. The State pays the incremental salaries of all recognized teachers in private secondary, vocational, comprehensive and community schools. A small amount called basic salary is paid to teachers in private secondary schools by their contractural employers, the clerical managing authorities. The position in relation to current expenditure is less rationalized thus requiring a detailing of arrangements for major institutional types. Current expenditure in secondary schools is subsidized by the Department of Education from central funds in two ways (1) capitation grants on a differential scale for junior and senior pupils, (2) payment of £30, subject to adjustment, per pupil for schools who have foregone their fees by opting for the free post-primary education scheme announced in 1967 [53]. Schools outside the free scheme receive capitation grants and continue to charge fees. Different arrangements exist for the minority Protestant population. A _per capita_ subsidy to Protestant children of post-primary school age is paid in a lump sum to the Secondary Education Committee for Protestant Schools, a joint committee representative of Anglicans, Presbyterians, Methodists and Quakers. This committee distributes the subsidy to parents, in accordance with a means tests, for their children's education [54]. The size of the subsidy, though roughly equal to that paid for Catholic children, is the source of considerable contention. On the surface Catholics and Protestants alike seem to be receiving the same level of subsidy from the State. However, historical circumstances have contrived to make Protestant education dearer than Catholic education and so the subsidy calculated to make post-primary education free for Catholics is less than adequate for Protestants. In an attempt to equalize matters the State has created 'Protestant' comprehensives to make post-primary education available free of charge for Protestant children in some areas. In comprehensive and community schools all current expenditure is borne by the State. The 1930 Vocational Education Act provides for the financing of vocational education partly through local rates and mostly through central funds. Current expenditure is shared by central and local authorities as is capital expenditure. The State bears total capital costs for comprehensive schools. 90 per cent of capital costs of community schools are assumed by the State while the participating religious body and local vocational education committee underwrite 5 per cent each. All capital expenditure for secondary schools was privately financed until 1966-67 when a scheme for grants for this purpose was introduced by the Department of Education [55]. In subsequent years the scheme was widened in scope and presently 70 per cent of capital costs are borne by the State and a loan of 30 per cent at favourable interest rates repayable over fifteen years is available for the remainder [56]. It is obvious from the above arrangements that the State is paying practically all capital and current expenditure in post-primary schools. In addition the Department of Education pays special grants to Irish and bilingual schools and other grants for a variety of different purposes, e.g. provision of audio-visual equipment. So that children generally avail of free post-primary education the State finances a free book scheme and a free transport scheme. The sixties period in Irish education especially from 1967 onwards has seen a marked increase in the State's financial obligations in post-primary education.

5. The School Health Service and Handicapped Children

A school Health Service is administered by the local authorities under regulations made by the Departments of Health and Social Welfare [31]. The local health authority provides free health services for all children including pre-school children at child welfare clinics. The school service includes dental, hearing and vision examinations. An important function of the Child Welfare and School Health Services is the identification of children requiring special education. In Ireland as elsewhere special education "has come to signify some form of educational provision adapted to the needs of those children who because of mental, physical, sensory and emotional handicaps are unable to benefit adequately from education in ordinary classes" [57]. The history of special education as such in Ireland is short, official recognition dating from comparatively recent times. Most of the recognized special schools have been established in the last forty years. Prior to that existing provision was mainly due to the efforts of voluntary bodies. The Department of Education [57] now recognises special schools "for children handicapped by marked intellectual, physical, sensory and emotional disabilities". These special schools which are of the day and residential type are organized in five categories (1) schools for blind and partially sighted children (2) schools for deaf and severely hard-of-hearing children (3) schools for mentally handicapped children (4) schools for physically handicapped children (5) schools for emotionally disturbed children [57]. All special schools operate under the regulations for ordinary national schools adapted or modified to suit their particular requirements in relation to pupil/teacher ratios, teacher qualifications and curriculum. In 1975 there were some 98 special schools serviced by 671 teachers catering for 7 303 pupils [51]. It is Department policy to make provision for mildly mentally handicapped children and other slow learners in special classes attached to ordinary national schools. Considerable progress has been recorded in the area of special education in the last twenty five years and is due to the combined efforts of religious and lay voluntary bodies and government agencies.

6. School Transport Service

The State provides free transport to national schools in every locality where there are at least ten eligible children. All children between the ages of 4 - 14 years who live at least three miles from the nearest national school are eligible for free transport; for children under ten the limit is two miles. In areas where small schools have been closed or amalgamated all children in the catchment area of the central school are entitled to free transport. The primary and post-primary transport services are integrated. Children attending post-primary schools are entitled to free transport if they reside more than three miles from the nearest post-primary centre. Public bus or train services are used whenever convenient, otherwise C.I.E. organizes special school bus services [50]. C.I.E., the semi-State national transport authority, maintains a fleet of special school buses but the service is augmented by private carriers. The free transport scheme does not apply in cities but the State subsidizes children's fares on public transport services. In 1975 the State paid for the transport of 65 745 primary pupils and 86 989 post-primary pupils at a total cost to the State of £10 665 973 [51].

7. The School-Going Population

School attendance is compulsory in Ireland between the ages of six and fifteen. The relevant statute is the School Attendance Act (1926). In 1972 the school-leaving age was raised from fourteen to fifteen by the Minister for Education in pursuance of this Act. The law is enforced in each of eight large urban areas by statutory school attendance committees and elsewhere throughout the country at local level by a specified officer from the local police station. Many children begin formal schooling prior to the legal age, at age three, four or five. These children are catered for in infant classes attached to national schools. On 30 September 1975 there were 130 465 children in infant classes out of a total of 518 921 attending national schools. Pupils normally spend eight years in national schools completing two infant grades and six standards before transferring to a post-primary school at 12+. A small minority of pupils remain on in national schools until age fifteen. In September 1975 the latest date for which official statistics are available, there were 63 923 pupils in sixth standard. Approximately 90 per cent of these transferred to post-primary schools while an estimated 1.6 per cent left full time education. The total school-going population for all types of post-primary schools aided and non-aided as recorded in September 1975 was 270 956. The estimated percentage of each age-group in full-time education the same date is as follows: (15) 86.4 per cent, (16) 68.6 per cent, (17) 46.0 per cent, (18) 27.2 per cent, (19) 15.3 per cent, (20 and over) 7.9 per cent (of the 20-24 age cohort) [51].

8. Higher Education

a. Non-university technical and commercial education.

It is convenient to examine higher education under two headings, university and non-university courses. Non-university higher education traditionally a small but lately a growing sector received a fillip in the 1960's. The needs of the economy set in sharp relief by the Investment in Education report (1965) and the report of the Steering Committee on Technical Education on Regional Technical Colleges (1967) focussed attention on higher technological and commercial education. Higher technician, commercial and professional courses hereto available in vocational education committees' technical colleges and colleges of technology were insufficient to supply to projected needs in trained personnel. Government intervention on a large scale was necessary and forthcoming. Increased participation in second level was a prerequisite for large scale increases in participation at third level. This problem was solved by the introduction of the Free Education Scheme in 1967. Direct Government intervention aimed at expanding the higher non-university sector materialized in the establishment of Regional Technical Colleges. A network of nine such colleges one each in Dundalk, Carlow, Waterford, Cork, Tralee, Galway, Athlone, Sligo and Letterkenny has been grafted onto the existing provision since 1969 making the third level non-university sector a major growth area in the education system. The country is now served by nine regional colleges, two colleges of technology in Dublin and a variety of other technical colleges in Dublin, Cork and Limerick catering for such things as commerce, retail distribution and building. In 1975 there were 23 vocational education committee schools and colleges including eight regional colleges providing third-level courses for a total of 6 331 full-time students [51]. In addition the National Institute for Higher Education Limerick opened its doors to students in 1972. This institute has a strong technological bias and in addition to diploma courses offers degree programmes in such areas as Business Studies, Administrative Systems, Engineering, Electronics and European Studies. Full-time enrolment was expected to reach 1 000 in September 1977. A sister institute is planned for Dublin. All these colleges with the exception of NIHE are controlled by local vocational education committees. They offer courses leading to higher technician-level qualifications in Science, Engineering and Business Studies and courses leading to examinations (or exemptions to examinations) of professional institutions. Courses vary in length from two years for certificate to three years for diploma. The Dublin Colleges of Technology viz. Kevin Street and Bolton Street in addition to certificate, diploma and professional courses offer some degree level courses. They have in the past, and continue to do so, offered courses leading to extern degrees (B. Sc.) of London University.

The rapid expansion in the non-university higher education sector has created a problem in that sector. The validation of awards had to be rationalized but arrangements in respect of degree awards have not been finalized. Traditionally long established technical colleges prepared students for British qualifications such as certificates and diplomas of the City and Guilds of the London Institute and examinations of various professional institutions, Irish and British, as well as Department of Education awards. In an attempt to rationalize awards in the non-university sector the Department of Education established a validating body in 1972, The National Council for Educational Awards (NCEA). The council has responsibility for establishing awards in the non-university technological/ commercial area. Initially the NCEA provided an alternative to university validated degrees, however, its degree validating powers were rescinded in 1974. The council was reconstituted in 1976 with "new functions of planning and co-ordinating, in addition to being the validation and award-making body for non-University Institutions of Higher Education" [58]. The degree validating function was restored to the NCEA by the Minister for Education in 1977. Government policy in pursuit of a comprehensive system of Higher Education in the period 1974-77 dictated university validation of all degrees. Restoration of the degree awarding function to the NCEA by a minister of the new government reverses this policy at least insofar as degree awards are concerned. It seems therefore that the universities will retain undiminished control in their traditional and developing areas while the NCEA will oversee degree, diploma and certificate awards in the emerging technological commercial sector of non-university higher education.

b. University Education

Ireland has two university institutions. Dublin University founded in 1591 has one college - Trinity College, Dublin. The National University of Ireland based on the old Queen's Colleges dates from 1908 Irish Universities Act. It has three constitutent colleges, one each in Dublin, Cork and Galway. St. Patrick's College, Maynooth occupies a dual position as a Pontifical University conferring degrees in Philosophy, Theology and Canon Law and a recognised College of the National University of Ireland providing degree courses in Arts and Science. Both universities are autonomous self-governing bodies. There is an independent medical school, the Royal College of Surgeons in Ireland founded in 1784. There has been a steady increase, approximately 1.9 per cent per annum, in total numbers attending university colleges full-time in the period 1970-71 to 1975-76.

In 1975-76 8 860 students were enrolled full-time at University College, Dublin; 3 980 at University College Cork; 3 131 at University College, Galway; 997 at Maynooth and 4 305 at Trinity College [59]. There were in addition 764 students attending the Royal College of Surgeons in the same year [59].

The universities are independent institutions but rely on State grants for capital expansion and current expenditure subsidies. The other major source of income is student fees. Previously all State funds to the universities were channelled through the Department of Education but the Higher Education Authority established by statute in 1972 has been entrusted with responsibility for co-ordinating activities financial and otherwise at third level. Government recurrent grant paid via the Higher Education Authority amounted to £548 per full-time student in university institutions in 1975. Approximately 26 per cent of all university students received grants in 1973-74 [60]. University grants are awarded on the basis of parental income and academic level attained on the Leaving Certificate Examination.

Each of the four university colleges provides the usual range of degree courses. Entrance to each university is based on the university's own matriculation examination with different individual requirements by faculty. At the National University the duration of first degree courses vary usually being three years in Arts, four years in Engineering, Dairy Science and Agriculture, five years in Dentistry, Veterinary Science and Architecture and six years in Medicine. A similar pattern obtains at Trinity College with the qualification that all first degrees are four year courses. Each university college offers post-graduate courses and between them there is a comprehensive range of higher degrees and post-graduate diplomas available. Some courses are available on a part-time basis. In addition each college puts a significant effort into its extra-mural studies programmes which follow different patterns by institution.

c. Teacher Education

There is a wide diversity of practice as regards the preparation of teachers for the school system. Teacher education is provided in Colleges of Education, in the universities and in a number of institutions catering specifically for such specialist subjects as domestic science, woodwork, art, physical education, motor engineering. Recent efforts of the Department of Education have been directed at rationalizing provision. The key to understanding the direction and form of this rationalization lies in the Department's policy for an all graduate teaching profession. All the Colleges of Education have been associated with university institutions for the purposes of gaining university validation of degree awards. These colleges are responsible for the preparation of primary teachers and require prospective teachers upon completing second-level to undergo a three year concurrent programme leading to a classified B.Ed. degree of the university. A small number of graduates are admitted each year to a one-year course before they qualify as national teachers. Second level teachers in the main are university graduates and many hold the Higher Diploma in Education, a post-graduate teacher qualification obtained in the universities. Secondary teachers of academic subjects must be graduates and in addition hold the Higher Diploma in Education. The vocational sector accepts graduates to teach academic subjects but the Higher Diploma of Education is not essential. Thus the bulk of teacher education and training, for post-primary schools, such as it is, is carried on in the universities.

Specialist teacher education and training is carried out in various centres under the auspices of the Department of Education. This includes various categories of teacher namely physical education, metalwork, woodwork, rural science, building construction, motor engineering, art and domestic science. These courses vary in length and entry requirements. The Department is in the process of rationalizing all such provision and much of it is being centralized in Limerick in a new college for specialist teachers, Thomond College of Education. Prospective art teachers are trained at the National College of Art and Design and at other centres for the Art Teacher's Certificate of the Department of Education. Domestic Science teachers are trained in St. Catherine's,Dublin and St. Angela's, Sligo, residential colleges, over a three year course leading to the appropriate qualification of the Department of Education.

The Colleges of Education are privately owned, denominational institutions under ecclesiastical control. They are State-aided and receive capitation grants and grants towards capital expansion. The amount of student fee is subject to the approval of the Minister for Education, as are certain other matters such as admission of students, student numbers and conditions of service of professional staff. Students i.e. prospective primary teachers are heavily subsidized by the State. Post-primary teachers receive no such subsidy and the cost of their education and training must be borne by themselves. Specialist teachers are usually recruited from the trades and course fees are remitted to the Department of Education. The Department also pays such recruits a weekly maintenance allowance. In 1975 there were 16 955 teachers in primary schools and approximately 15 699 full-time teachers in post-primary schools [51].

9. Adult Education

A variety of agencies, voluntary, religious and governmental are involved in one way or another in adult education. Vocational education committees in pursuance of the 1930 Vocational Education Act are the main statutory providers of adult education. These local education committees respond to local needs by sponsoring a great variety of courses and lectures in vocational schools and technical colleges. They provide mainly part-time vocational courses but also provide liberal studies and recreational classes. The regional technical colleges, heirs to the vocational education committees' tradition in adult education provision, have not neglected this area and are generally active.

For the most part, vocational schools excepted, the schools have not been active in providing opportunities for adult education. However, recent developments in the post-primary sector promise better for the future. The development of comprehensive and community schools and the emphasis on community involvement and use of school facilities outside normal class times has led to increased use of these centres as places for adult education classes. Indeed the community schools document [46] issued by the Department of Education in 1970 stressed this role of the schools.

The university institutions make a significant contribution to adult education provision through their departments of extra-mural studies. Some colleges conduct these courses in out-centres in their geographical catchment areas. Significantly University College, Cork, has established a Department of Adult Education in recent years.

A variety of voluntary organizations have been active in adult education over the years. The Irish Countrywomen's Association, Macra Na Feirme and other farming organizations provide numerous courses and seminars for their members. The Irish Congress of Trade Unions also is active in the interests of its members promoting short courses on union related matters. The Churches too by virtue of their mission to teach are involved in adult education. Much of their provision is integrated with the work of lay-apostolate organizations. Many national voluntary agencies are affiliated to the National Association for Adult Education (Aontas). Aontas has individual membership and numbers some 120 adult education agencies both voluntary and statutory. Aontas seeks among other things to influence national policy in adult education and to promote an awareness of the concept of permanent education [61].

Many government agencies sponsor adult education directly or indirectly. The Department of Agriculture, for example, through Agricultural Advisory Service conducts a significant formal adult education programme. The Industrial Training Authority under the Department of Labour is statutorily charged with responsibility for the initial training of apprentices, for the training of unemployed and redundant workers and updating skills of workers in industry. The Irish Management Institute under the auspices of the Department of Labour and the Institute of Public Administration under Finance make significant contributions in the area of adult education.

In view of the varied provision it is not surprising that the committee [61] appointed to examine adult education provision in Ireland emphasized that the greatest single need was the organization and coordination of a definite framework for adult education. The work of this committee has pointed the way forward : adult education must be seen and developed as one aspect of an integrated system of permanent education.

CHAPTER IV

THE IRISH EDUCATION SYSTEM III : THE SCHOOL SYSTEM[1]

1. Primary Education - The First Level

No explicit official definition of primary education is ready to hand, nor can one point to a legal definition since there is no comprehensive Education Act for Ireland. However, the nature and purpose of primary education in Ireland may be inferred from the origins of the system and the practices and policies of successive governments. Irish educational history reveals a definite evolution in the concept of primary education.

2. Evolution of the concept 'primary education'

The genesis of the present system of primary education is to be found in the social and political milieu of the half-century period spanning the late eighteenth and early nineteenth centuries. Educationally this period is remarkable in Irish history because of the work of the voluntary church societies for the education of the poor. The Kildare Place Society, the most important and successful of these societies, left a legacy in education unsurpassed in Ireland or indeed in Europe at that time. The system of national education instituted by Stanley in 1831 was modelled on the Kildare Place Society system of schools. Subsequently the Commissioners of National Education relied heavily on Kildare Place Society's practice in school organization including

---

1. The 'school system' encompasses the formal educational activity associated with the first and second levels of education and specifically excludes education which might be viewed as third level education, higher education, further education, etc. See discussion, page 61.

inspection [62]. Thus the system of national education confirmed a tradition in education which saw primary education as essentially a charitable enterprise conducted on behalf of the poor. The term 'national education' only thinly veiled the official attitude of the time; it was synonymous with elementary education for the poor provided by the State at minimum expense. The national schools were basically *literacy and numeracy schools with the emphasis on reading, writing and arithmetic*. Further, these schools were likely to be the only schools attended by the vast majority of the people. National education therefore was both elementary and terminal.

The 'payment by results' system introduced into the system of national education upon the recommendation of the Powis Commission had serious undesirable effects on national education. The bookish nature and narrowness of primary education was accentuated. This in turn precipitated the inquiries of the Belmore Commission (1897) which led to a radical revision of the national schools' curriculum and the abolition of the 'payment by results' system. The Revised Programme of National Education was announced by the resident commissioner Starkie in 1900 and the emphasis was on a wider range of subjects including hand-eye subjects and elementary science. The Belmore Commission's concern for these subjects together with its recommendations regarding the extension of the kindergarten system to as many schools as possible betrays a conception of primary education which is both child-centred and utilitarian. Implicitly the Commission confirmed the traditional view of primary education as a minimum education but extended the minimum beyond the long accepted three R's.

Some pupils remained in national schools until they were eighteen years of age availing of this minimum education. Initially no one was compelled to attend national schools but State intervention in the interest of the common good was marked by the introduction of compulsory attendance laws (1892, 1926). Citizenship had its obligations and towards the end of the nineteenth century every citizen was obliged to have a minimum education. In this way age became a relevant factor in primary education as compulsory attendance necessitated designated ages. The legal ages adopted in the 1892 Act [63] and again in the 1926 Act [64] were six and fourteen years. Compulsion introduced another important consideration the State could only require pupils to attend school if it provided such education free of charge. National education in Ireland was available free of chrage in the majority of schools from 1892 [7]. The right of every citizen of the independent Irish State to free primary education was acknowledged and the State undertook to provide such education in national schools. Thus primary education spanned a period of free compulsory schooling usually concluded by age fourteen which point invariably marked the end of formal schooling.

For many years the State in an independent Ireland viewed primary education as the only formal education a large proportion of its citizens was likely to receive. Primary education was designed to provide pupils with the basic skills necessary to complement those developed in the home [7]:

> Traditionally the term "primary school" has been applied to that stage in which children acquired the essentials of education complementary to the fundamentals acquired in the home. These essentials included religious doctrine and practice and a sufficient knowledge of reading, writing and arithmetic to guarantee the average child in later life a fair chance of success in at least unskilled occupations.

The desire to equip children as fully as possible for the demands of later life was an important aim of the primary school. This led to an emphasis on proficiency in reading, writing and computation, the elements on which success was thought to be based . Towards this end the State introduced a syllabus of instruction in each subject for each standard. The terminal aspect of primary education is highlighted by the introduction of a State Primary School Certificate which was intended as a 'leaving' certificate. This State examination in English Irish and Arithmetic was compulsory for all pupils completing Standard VI in the period 1943-67 having been optional since 1929. Prescribed syllabuses in each subject and the compulsory Primary School Certificate contributed to *a general uniform standard and an extreme 'subject-centred' approach to primary education.*

Although the Primary School Certificate was not officially abolished until 1967 there was a growing realization in the preceeding years that primary education was, in an important sense, preparatory for further education. This had always been the case in practice for the minority of pupils who proceeded to secondary education. But this preparatory aspect of primary education had never been officially acknowledged. However, the steady increase in numbers of pupils aspiring to secondary education caused a re-evaluation of the role of the primary school. The Council of Education [7] in 1954 described the function of the primary school as follows:

> The primary school therefore serves two purposes; it provides a basic education and it prepares the child for further education should he receive it. It is not to be expected that the primary school can, within the range in which we have placed it, impart the full minimum education that is to-day regarded as necessary but it can provide such a foundation as will answer the common needs of all.

Thus long before the Department of Education abolished the primary school 'leaving' certificate i.e. the Primary School Certificate, the preparatory nature of primary education had been recognized and a acknowledged. The essentially preparatory function of primary education has since been officially confirmed and together with the child-centred approach fostered by the new curriculum represents current official thinking on the matter as confirmed by following quotation [65]:

> The aims of primary education may, therefore briefly be stated as follows:
>
> 1. To enable the child to live a full life as a child;
>
> 2. To equip him to avail himself of further education so that he may go on to live a full and useful life as an adult in society.

These developments coincide with an attitude *which sees primary education as the foundation on which all further formal education is built* [66]. And a change in methodology from a subject-centred pedagogy to a child-centred one is a fundamental tenet providing motivation for the new curriculum in primary schools.

Although originally intended by the State to cover the period of compulsory education, primary education is not now normally extended beyond the age of twelve. The majority of children now transfer to post-primary schools at 12+. This is not a new feature of education in Ireland. The State had, among other things, coordinated the educational sectors so that secondary and continuation education followed the completion of sixth standard [7]. The Council of Education pointed to official policy (just mentioned) to support its view that primary education was concluded when the child completed Standard V1. Pupils could, if they so wished, complete their compulsory schooling in national schools but the work in standards beyond the sixth was based on the secondary school curriculum. With the introduction of comprehensive education after 1963 a period of post-primary education was projected for *all children as a matter of government policy.* The general availability of free post-primary education after the introduction of the Free Education Scheme in 1967 resulted in the realization of government policy. Today children invariably complete the last years of compulsory schooling in a post-primary school. It is essential therefore that primary education does indeed prepare pupils for further formal education. The added emphasis on the preparatory and foundational aspect of primary education is largely the result of the universal availability of second-level education in Ireland. It is now generally accepted in Irish educational circles official and otherwise that primary education is but the first stage in a child's education.

3. The Primary School

The majority of Irish children (more than 95 per cent) attend State-aided national schools [50]. A very small minority go to fee-charging private schools. Primary education normally begins at age six in first standard and continues through sixth standard encompassing a six year course. Whether all six standards are completed in the same national school depends upon the local circumstances. Most Irish children begin their school careers between the ages of four and six, the modal age being five years. As a rule children spend two years in infant classes attached to national schools. However, no normal child aged six and a half years or older may be retained in an infant class. Co-education in national schools is not promoted nor is it pursued as a deliberate educational policy. Most co-educational national schools are small rural schools where economic necessity rather than educational policy dictated the state of affairs. The Irish Catholic Hierarchy's position is clear; *the ideal is single sex schools for boys and girls*, an exception being made in rural areas where the viability of a school is in question [15].

The problem of small schools has been a persistent one in Irish educational history. Successive administrations, British and Irish, have addressed the problem in the past with varying degrees of success. A policy of amalgamation of small schools was embarked upon even before the founding of the modern Irish State and pursued by successive Irish administrations. The Investment in Education (1965) report highlighted the problem in sound statistical terms and a policy of amalgamation was pursued with renewed vigour as a consequence. Zeal has waned in recent years following a greater official awareness of the social value of small schools developed in the turmoil of local resistence to closures. If economic and educational efficiency are no longer the only criteria for closure or amalgamation the problem is no less difficult and urgent while more than 50 per cent of Irish national schools are either one,two or three teacher schools.

National schools in urban centres in Ireland differ in many important respects educationally from small rural national schools. National schools are all-age schools. Thus in one-teacher schools the teacher is in charge of children of different ages in the same classroom at the same time. The situation is slightly improved in two and three-teacher schools. This contrasts sharply with urban national schools where facilities are generally such as to allow grading of pupils into standards with a teacher assigned to each standard. Nevertheless the situation is difficult since the pupil-teacher ratio is unfavourable with as many as fifty pupils to a single class. The national pupil-teacher ratio is over 40 : 1. If equal educational opportunity for all Irish children is a major objective of educational policy in Ireland then much remains to be done at primary level in the pursuit of this objective.

4. Pedagogy and the Primary School Curriculum

The curriculum of Irish primary schools experienced an unusually long period of stability, compared with other Western countries, extending from 1831 to 1971. This is not to say that there were no changes in the curriculum but rather to insist that such changes as did occur were evolutionary rather than revolutionary in nature. Even the political upheaval concom itant with the founding of the modern Irish State did not materially affect the school curriculum excepting the position of the Irish language. The Irish Free State government did not alter the structure of the educational systems it inherited from the previous Administration but continued them in their essentials. It was not until 1971 that one could say with conviction that there was a definite break with the curricular practice extending back to the Commissioners of National Education. Two periods, therefore, stand out in a study of the curriculum in Irish primary schools since independence namely the periods 1922-1971 and 1971 to the present.

The curriculum is influenced by a variety of factors such as histroical and political circumstances and socio-economic factors. At the outset the curriculum in Irish schools, especially the primary schools, *seems to have been influenced more directly by political considerations than* *anything else*. As Coolahan [67] puts it, much of the thinking in relation to educational programmes "was based on fixed ideological or political viewpoints rather than on a sound foundation of educational theory and practice". The case for independence was based on a concept of nationalism rooted in the nineteenth century doctrine which equated nation with people possessing a distinct language and bearing an individual culture; and further such a nation ought to constitute a state. After independence was won nothing short of the complete revitalization of Irish culture was envisaged and the cultural revivalists, many of them politicians and educationalists, viewed the school as the principal agency in this cultural restoration. Adding greater significance from an educational viewpoint is the fact that "the revitalizing of Irish was to be centred on the preservation and extension of Irish as a living language" [67]. Irish became a compulsory subject in the primary school curriculum in 1922 and quickly assumed an importance in the curriculum surpassing all other subjects except religion. The emphasis in the primary school curriculum remained firmly on the Irish language as the principal means of effecting the *political objective* of a cultural revival.

In the period 1922-1971 the primary school curriculum i.e. the traditional curriculum remained solidly rooted in the recommendations of the First National Programme Conference, a meeting of educationalists convened by the Irish National Teachers' Organization in 1921. These recommendations were accepted by the Provisional Government of the Irish Free State in 1922 and chief among them were proposals for a reduction in the number of obligatory subjects allied with the introduction of Irish as a compulsory subject. The Conference recommended an *obligatory core* of Irish, English, Mathematics, History, Geography, Singing, Physical Training and Needlework [7]. The Second National Programme Conference (1926) convened by the Minister for Education and attended by leading Irish educationalists endorsed the spirit underlying the recommendations of the First Conference but modified them in relation to the Irish language proposals. Nevertheless Irish remained a compulsory subject in primary schools. The deliberations of the Second National Programme Conference led to the introduction of a new curriculum in primary schools which included Religion, Irish, English, Arithmetic, History, Geography, Music and Needlework (girls) as *obligatory subjects*. Rural Science or nature study, Algebra and Geometry were only compulsory under certain conditions but never in one-teacher schools. A range of optional subjects were listed and included Drawing, Physical Training, Cookery or Laundry-work or Domestic Economy (for girls) and manual instruction (for boys) [7]. *No major changes in the primary school curriculum were implemented until 1971.* Therefore a traditional curriculum can be identified with the period in question.

The curriculum of Irish primary schools is subject to *a high degree of centralized control*. While it is true to say that this particular aspect of primary education is a legacy from British rule it is equally fair to say that the Irish government has since made no serious effort to decentralize control of education. At primary level the control is exercised directly through official publications such as the Programme of Primary Schools [68] and very recently the Primary School Curriculum (1971) [69].

The traditional curriculum was greatly influenced by the Primary Certificate Examination which was compulsory for all pupils completing Standard VI in the period from 1943-1967. This factor together with the extreme academic nature of the traditional secondary school programme contributed to an academic subject-centred approach to teaching in primary schools. This subject-centred pedagogy remains one of *the principal distinguishing characteristics of the traditional Irish primary education.* It contrasts sharply with the approach to the new curriculum introduced in 1971. The contrast is highlighted in the following passage [69]:

> This approach is logical rather than psychological and places emphasis on what the child ought to be taught rather than on how he learns at the different stages of his development.

The new curriculum is consequently integrative in nature and is intended that it be taught as an *integral whole* without sharply different parts. It is unencumbered by rigid subject barriers and time-tables and *is free from the influence of extern examinations.* The principal aspects of the new programme are Religion, Language, Mathematics, Social and Environmental Studies, Art and Craft activities, Music and Physical Education [69]. Significantly religion continues to be the most important subject in the school curriculum. It is "a fundamental part of the school course, and a religious spirit should inform and vivify the whole work of the school" [31]. The Department of Education *supports the central significance of religion for the school* but refrains from prescribing syllabuses, setting examinations or supervising its teaching in schools. All this is the province of the Church authorities and the local clerical manager is responsible to his Bishop for religious instruction in his school. The child-centred approach implicit in the new curriculum has been extended to the new cathecetics classes for children so that the break with the traditional curriculum is complete across the whole spectrum of primary school activities.

Changes in pedagogical practice and school organization were anticipated with the introduction of the new curriculum in 1971. The integrated nature of the new curriculum and its underlying philosophy demanded a reappraisal of the role of the teacher, more resources to support the programme and a greater flexibility in the timetable. The ideal to be attained universally in the primary schools was a classroom practice informed by psychological principles and more in accord with recent educational research in which the child is "seen to be the most active agent in his own education" [69]. A child-centred approach to education was not new to Irish teachers. As early as 1898 the Belmore Commission recommended an extension of Kindergarten methods to infant classes in national schools [7]. Since 1951, teachers of infant classes have acknowledged the necessity of catering for children as individuals and helping them to realize their potential individually. The application of these principles to all classes in primary schools is what was envisaged under the new programme. Since its introduction into 600 national schools in 1971-72 on an experimental basis the new curriculum has supplanted the traditional one in Irish education. The scale of the operation and the magnitude of the change inevitably caused problems, problems which have yet to be resolved satisfactorily. It is not at all definite that the programme can be offered and supported in an honest form when large classes of over 40 pupils are involved. Nor is it clear that the programme is viable in small schools. What is clear, however, is that the new curriculum is more liberal than the traditional one: *that there is extensive use of individual and group learning methods and that pupil initiative and activity is encouraged in the classroom.*

5. Post-Primary Education - The Second Level

Second level education for most Irish children begins at 12+ upon completion of sixth standard. The Department of Education encourages the transfer of pupils from primary to post-primary schools at around twelve years of age. There is a variety of post-primary school types. An exhaustive listing includes privately owned denominational Secondary schools, State owned Vocational schools, Comprehensives and jointly owned Community schools. The law requires that children between the ages of six and fifteen years attend school. Thus, the normal practice now ensures that each child attends a post-primary school for approximately three years. The whole five year post-primary programme can usually be completed by the pupil's eighteenth birthday. *The State for its part is committed to a policy of equal educational opportunity for all children.* Consequently the State provides free post-primary education for all children under the provisions of the free education scheme introduced in 1967. As a means of ensuring open access to post-primary schools for all children *The State has discontinued selection.* This current position represents a drastic change in official attitudes towards post-primary education; a change which happened quickly but nevertheless was a long time coming when viewed in the context of the evolution of post-primary education in Ireland.

6. State Attitude Towards Post-Primary Education

There is abundent evidence of change in official attitude towards post-primary education since independence. The State inherited a public system of Technical schools and a private system of Secondary schools each operating at post-primary level with completely different objectives in education. Initially, and for many years after the founding of the State, the Government avoided direct involvement in the expansion of post-primary educational provision in the private denominationally owned Secondary schools. However, the inherited financial obligations towards the Secondary (Intermediate) schools were honoured and even put on a new basis with the replacement of the 'payment by results' system by a capitation grant based on the number of recognised pupils in recognized Secondary Schools i.e. schools which satisfied the conditions promulgated in the annual publication of the Department of Education known as Rules and Programme for Secondary Schools [32]. The State was obliged to honour its inherited responsibilities but was under *no legal obligation to expand post-primary provision.* There was no competing system of post-primary schools thus leaving the Secondary schools and their academic grammar-school type programme *unrivalled* in Irish education.

The Government was careful not to encroach on the prerogatives of the Catholic Church in secondary education. Besides the financial resources required for a State take-over of secondary education were beyond the means of the State at that time or at any time since. Even if the resources for such an undertaking were available the Government did not harbour the desire to effect it. *There was little difference between the Government's and the Church's policy in secondary education.* And for each the idea and commitment to free universal secondary education was yet a long time in the future. The development of secondary education in the period from the founding of the State until the sixties was left therefore, by and large, to private interests, namely, the various religious bodies. These factors, together with the belief that secondary education was a type of education rather than a stage in the educational process, contributed to State indifference in secondary education during this period.

The State's attitude to secondary education contrasted sharply with State involvement in technical education in the same period. Motivated by the need for skilled manpower the State has since its inception played *a direct and active part in technical education.* The Technical Schools then, and as they subsequently developed, provided the only other form of post-primary education in Ireland for many years. The State reorganized and expanded technical education under the provisions of the Vocational Education Act, 1930. This Act incorporated the recommendations of the Commission on Technical Instruction reported in 1927 [69]. The development of day continuation schools, a new feature in Irish education, derives from this Act. Continuation education is legally defined in the Act as [18]:

> education to continue and supplement education provided in elementary schools and includes general and practical training in preparation for employment in trades, manufactures, agriculture, commerce, and other industrial pursuits, and also general and practical training for improvement of young persons in the early stages of employment.

Continuation education, therefore, coincided with a full-time course of general education based on technical subjects, of two years duration and with the immediate objective of enabling pupils to take up employment. It was designed to act as "A bridge between general education terminating at 14, and either early employment or the narrow and more specialised technical education, commencing not earlier than 16 " [25]. A more recent document (Memo V.40 Department of Education) published in 1942 elaborated the concept of continuation education as defined in the Act and generally charted the course of future development. This document remains to this day the *definitive statement* on continuation education in Ireland. In time continuation education came to be seen as an alternative to secondary education especially after a relaxation of the age requirement for entry which had the effect of articulating it more directly with primary education.

Vocational education is a generic term which was coined for the purposes of the 1930 Act. It covered continuation and technical education as defined in the Act. The legal definition of technical education given is [18]:

> education pertaining to trades, manufactures, commerce, and other industrial pursuits (including the occupations of girls and women connected with the household) and in subjects bearing thereon or relating thereto and includes education in science and art (including, in the county boroughs of Dublin and Cork music) and also includes physical training.

Facilities for technical education were developed in the larger vocational schools and the courses generally part-time in nature led to the Department of Education's Trade Tests and Technological Certificates. For many years the technological Certificates examinations were the only examinations at technician level in certain occupations. Until the advent of the Regional Technical Colleges in the early seventies facilities for higher technical courses were concentrated mainly in Dublin, in Bolton Street and Kevin Street Colleges of Technology with some higher level facilities in Cork and Limerick.

The Vocational education system, State-controlled and locally administered under the Act, experienced a steady expansion in facilities and pupil numbers and remained completely independent of the Secondary system during the period in question. While it may be true to say that vocational education provided an alternative form of post-primary education from the outset it should not be inferred that it competed with secondary education. The question of competition never arose because of the different ends of vocational and secondary education *but more importantly because Irish parents traditionally held secondary education in higher esteem.* This attitude remained fixed without discernible change until the late fifties when political and economic factors forced a reappraisal.

It was not until the early sixties that a major shift in Government policy towards post-primary education became noticeable. By this time more and more Irish children aspired to secondary education. The growing demand for places in Secondary schools in particular and post-primary schools generally could not be met without a major expansion of the private Secondary school system and the Vocational system. Matters were complicated educationally by the generally held belief that the educational system should be more responsive to the needs of the economy. Expansion in the Vocational sector was advocated on the basis of this sector's anticipated importance in fulfilling the nation's requirements in skilled manpower for agricultural and industrial development. There was mounting pressure too for the raising of the school leaving age to 15. The financial obligations inevitably incurred by the State in any extension of the period of compulsory education were more than the State was willing to accept in 1959. In the Dail that year, the Taoiseach, Mr Lemass outlined Government policy [70]:

> The aim of Government policy is to bring about a situation in which all children will continue their schooling until they are at least fifteen years of age. We intend to strive to achieve that situation with the least possible delay. Our view, however ... is that statutory compulsory attendance at schools up to fifteen years is not in present circumstances the best way to achieve the end we have in view ... Our immediate policy is to increase the facilities for post-primary education.

This was tantamount to promoting a voluntary extension of attendance at school by extending post-primary educational provision. This policy was directly implemented in the State controlled Vocational sector which was expanded greatly in the early sixties but the private Secondary sector posed problems. The financial incentive required by the management of Secondary schools came in the form of a building grant, announced in 1964, the first such grant made available by the State. The State's attitude towards post-primary education remained inextricably intertwined with its policy on eductational provision and its willingness to accept the enlarged financial commitment implicit in a large-scale extension of facilities.

But these developments cannot be divorced from the ideological basis of the State as a democracy. The democratic ideal of equal educational opportunity was beginning to make an impact on educational thinking in Ireland in the fifties, and by the mid-sixties had become the cornerstone of all educational policy in Ireland. Successive education ministers have carried on the process, begun by Dr Hillery in 1963, of making the educational system more democratic especially at second level. In 1963 Dr Hillery [21] announced plans for the erection of State-sponsored comprehensive schools, *a new departure in Irish education.* His concern was to remedy *structural defects* in the system of post-primary education which militated against equal educational opportunity for all children. It is interesting to note that the conduct of secondary and vocational sectors as independent non-overlapping systems was highlighted as a serious defect in post-primary education although such a development had been facilitated by the State since independence. The other serious defect was the absence of post-primary facilities in many areas of the country. The Minister viewed the introduction of comprehensive education as a means of securing some post-primary education for all Irish children. This was followed by a determined effort on the Government's part to remove all educational and financial barriers to participation in post-primary education. *Changes designed to raise the status of vocational education were introduced.* Selection for post-primary schools was discontinued by the Government in 1966. In 1967 the Minister for Education, Mr Donogh O'Malley introduced the free education scheme removing the last major financial barrier to access to post-primary schools. The State would henceforth provide free post-primary education for all children. The Government's commitment to the ideal of equal educational opportunity only discovered in the late fifties, moved the State from an attitude which accepted only primary education as a birthright to an intermediate stage of some post-primary education for all and ultimately to the acceptance of free post-primary education for all.

The *economic impetus* for the reorganization of post-primary education in the sixties cannot be denied. It followed the introduction of large-scale economic planning into Government affairs in the late fifties. The Second Programme for Economic Expansion (1963) [20], the Government White Paper on the economy explicitly acknowledges the role of education in economic planning. The State began to invest in its children as a means of securing its future. Economic planning demands efficiency and thus *efficiency* became an important aspect of educational planning and has directly influenced educational policy especially since the publication of Investment in Education in the early sixties. One is compelled to accept a concurrence of political ideology, the demands of the economy and educational development during this period as more than accidental. The determined attempt to mould post-primary education along comprehensive lines inaugurated by the unprecedented direct involvement of the State in Comprehensive schools and the evolution of Community schools, arises from the same well-spring of inspiration. And post-primary education in the process has been firmly established as the second of the three stages of education.

7. Selection and Guidance

Selection for post-primary education has been relatively uncontroversial in Ireland compared with other countries, e.g. the U.K. The reasons for this are for the most part uncomplicated. From the inception of the State until very recent times, the parallel systems of secondary and vocational education taken together represented the totality of post-primary educational provision. The State-controlled Vocational system offered courses which were employment oriented and of short duration, the longest full-time course being the two-year day continuation course. The State was anxious for economic and educational reasons to attract pupils into vocational education. Thus the question of selection never arose since all that was required was the completion of one year in sixth standard and attainment of a minimum age. The cost factor to pupils was negligible since the fees charged were minimal or waived. However there was *no ladder to third level education* in this sector for many years. Thus a full course of secondary education was only available in private fee-charging institutions under denominational control. It is important to note, therefore, whatever its attitude toward selection, that the State was not in full command of the situation. In return for aid the State sought evidence that those aspiring to secondary education could benefit from it. For this purpose an entrance examination based on sixth standard work in Irish, Arithmetic and one other subject was conducted by school managers. The manager was responsible for marking the examinations and retaining the scripts for one year for inspection by Department officials. This procedure never assumed the dimensions of a system of competitive selection for two reasons: (1) in practice the Department and school managers rarely denied pupils access to Secondary schools for reasons of failure on entrance examinations (2) there was no need to limit the number of pupils entering Secondary schools since the number of places exceeded or kept pace with the demand for many years. However, the practice gave rise to streaming in Secondary schools in later years, a practice which continues in many Irish schools today *despite the official rejection of selection for post-primary schools.*

A different kind of selection was at work during this period i.e. social discrimination in education. It was not promoted actively or condoned but yet the State was not without blame. Clearly secondary education was seen to be beyond the means of all but middle and upper class families. But the State's meagre scholarship provision could hardly be seen as a serious effort to alleviate matters. And so matters remained until the sixties when the ideal of equal educational opportunity became an important factor in Irish educational policy [38].

It is difficult to decide whether subsequent development in the post-primary sector was motivated by allegience to the principle of equal educational opportunity or if equality of educational opportunity became the banner under which the State marshalled nerve and support to align the post-primary sector more closely with the interests of an awakening economy. However it is clear that there was a growing demand for secondary education promoted mainly by the steadfast belief of parents in *educational achievement* as the surest route to the realization of their social ambitions for their children. This growth in demand for post-primary education coincided with the economic ambitions of the Government. Education was acknowledged *explicitly* as an essential element in Government plans for economic growth.

Whatever the causes were, the State belatedly acknowledged its obligations in second level education. The rapid advance to the provision of free post-primary education for all in 1967 followed directly from the State's assumption of the enlarged responsibility in post-primary education in the late fifties. A significant step was taken in 1963 when the Minister for Education introduced comprehensive education as *an educational principle and a desir able educational objective*. The comprehensivization of Irish post-primary education proceeded from that date. By 1967 the State had discontinued the entrance examination to Secondary Schools and abolished the Primary Certificate Examination replacing it with a system of school-based assessment. Transfer to post-primary schools became automatic for all pupils completing sixth standard and principals would henceforth be guided by the pupils' cumulative record cards.

The need for guidance was acknowledged when Comprehensive schools were introduced. It was envisaged that pupils would have the benefit of guidance from educational psychologists during the early years of second level education [21]. This led to the establishment of a two-tier pupil guidance service by the Department of Education's Psychological Service. At first the service was confined to the new State comprehensive schools but it was envisaged that the two-tier service would eventually operate in all post-primary schools [38]. The plan provides for the training of selected teachers at short courses supported by the Department's professional service. Many teachers have been trained in this manner but the service as projected has fallen short of the target and while many schools throughout the country are serviced many more are not.

The comprehensivization of Irish post-primary education was seen as a means of attaining policy objectives in education. And as Sean O'Connor then Assistant Secretary in the Department of Education, stated in 1968 "These are (1) equality of educational opportunity for all, and (2) the fashioning of education so that it is responsive to the aptitudes and interests of the individual pupil" [38]. The Department of Education saw the comprehensive school idea and its particular manifestation in Ireland "providing for each *individual* student an education structured to his or her needs and interests, and providing specialist guidance on his or her own particular abilities and aptitudes" [71]. In this context guidance replaces selection. It is noteworthy that the Department of Education leaves the choice of school career etc., to the pupil and parents. He is directed towards the courses best suited to his abilities but no attempt is made by strict selection or otherwise, to determine the type of education to be followed by the pupil. However many Secondary schools still select pupils on the basis of an entrance examination as a means of filling places which are oversubscribed. *This practice is unlikely to change in the near future nor is the allied practice of streaming based on such examinations likely to change either.*

8. Curriculum and Examinations

The curriculum in Irish post-primary schools has been influenced by many factors historical, socio-economic, political and educational. A clear understanding of the present position is impossible without the perspective afforded by historical background. Recall that private denominationally owned and run post-elementary schools became numerous after the relaxation of the Penal Laws at the close of the eighteenth century. The course of instruction was the academic grammar school-type designed to prepare young aspirants for the Church. Hence there was a very great *classical bias*. This bias persisted and was accentuated under the Intermediate Education Commissioners. After the passing of the Intermediate Education Act in 1878 State aid was made available to all intermediate schools for the first time. The 'system of payment by results' was instituted under the provisions of the Act and monies became payable to schools on the basis of examination results obtained on single-subject syllabuses prescribed by the Intermediate Eduacation Board. By acting as an examination authority the Board was able to dictate the type of education pursued in the schools. And so it did until its abolition in 1923. The year 1879 marks *the advent of extern State examinations* into Irish education, a practice which has continued uninterrupted until the present day.

Since no other yardstick besides the pupils' performance on the Board's public examinations could be used to assess the school's worth for financial support, the examination system inevitably had a tremendous bearing on the school syllabus, and the way it was taught [67]. Examinations became the universal measure of scholastic achievement in Ireland as in fact they had become in most other countries but especially in Britain. The effect of the Board's examinations was pervasive for simple economic reasons. If schools wished to obtain aid from the Commissioners they had to comply with their rules and regulations and accept a common curriculum and syllabus. And no school could afford to forego government aid. Examinations were governed by the rules contained in a schedule appended to original Act in 1878. These rules continued in force until amended in 1900 upon the recommendation of the Board itself which was constituted as a Commission of Inquiry. Originally the Board's examinations were single-subject examinations. The subject to be examined were grouped into seven divisions and there were examinations in three grades, Junior, Middle and Senior. These divisions favoured English, Latin and Greek which were promoted in other ways by an allocation of extra marks and greater financial rewards for studying these subjects [11]. These factors perpetuated the *literary or classical bias* in Irish intermediate schools.

The Intermediate Education Commissioners were acutely aware of their own limitations under the Act and the undesireable effects of the Act on education in Ireland. The chief criticisms levelled at the system as it existed at the close of the nineteenth century were (1) the inordinately great influence of examinations on the system and (2) the widespread practice of cramming, (3) *an unduly high allocation of time and effort devoted to the study of the classics to the detriment of scientific subjects.* The practice of awarding aid solely on the criteria of examinations results was unsatisfactory and pointed to the need for a permanent inspectorate. The Commissioners prevailed on the Lord Lieutenant to institute an inquiry and he in turn appointed the Board to act as a Commission of Inquiry in 1898. The Commission submitted its recommendations in 1899. Their recommendations were endorsed by the Intermediate Education Act, 1900 and the Rules and Regulations of Examinations for 1902 were based on them. The major departure was the change from the single-subject system to a group system. Two separate courses in each grade were introduced and were known as the Grammar School Course and the Modern Course. A further division into four distinct courses took place in 1903 and these separate courses were known as the Classical, Modern, Scientific and Mathematical Courses [11]. However the tendency to study a central core of subjects such as English, French, Irish, Latin, German, Mathematics and Geography and possibly Science was evident and the practice remained prevalent during the life of the Board [67]. Several passes in individual subjects contributed to an overall pass in the examination.

A new programme based on the recommendations of the Dail Commission (1921) was introduced in 1924. The Junior, Middle and Senior Grade Examinations were replaced by two Certificate Examinations. The junior course of three or four years duration would lead to the Intermediate Certificate Examination which was "intended to testify to the completion of a well-balanced course of general education for pupils who leave school at about 16 years of age" [11]. The student had to pass in five subjects including Irish or English, Mathematics, a second language, History and Geography or Science, Latin or Greek. The senior course followed immediately upon the junior course and was of two year's duration. It led to the Leaving Certificate Examination which was intended to "testify to the completion of a good secondary education, and to the fitness of the student to enter on a course of study at a University or an educational institution of similar standing" [11]. The student was required to pass in any five subjects from the Department's recognized list provided the selection included either Irish or English. These arrangements in secondary education proved particularly durable and there were no major changes in the curriculum until the sixties. In fact the *first modern innovation* in secondary education was the introduction in 1957 of an oral Irish test as part of the Leaving Certificate Examination.

The curriculum in secondary schools has been dominated by the extern examinations of the central authority namely the Department of Education. The examination syllabus in each subject is prescribed by the Department and the Department is responsible for setting and marking the examinations.

This has led to a uniformity of pedagogical practice and educational standards throughout the country. The curriculum remained singularly academic and classical with as much as 50 per cent of the students' time devoted to classics while only 10 per cent approximately was devoted to physical sciences and biology [66]. Classical humanism appropriately describes the ideological basis of the Secondary school curriculum which was reinforced by the other-worldly basis of secondary education. Religious instruction was, and still is, fundamental to the whole school programme and is recognized by the State as one of the most important subjects in the curriculum [50]. The State ensures that religious instruction is part of the programme but does not prescribe courses or examine them. In the words of the Council of Education "The provision of programmes of instruction in religion at all stages and their supervision pertain to the authorities of the religious denominations to which the pupils are affiliated" [11].

It has been noted that the course of secondary instruction leading to the Leaving Certificate was designed *with a view to university entrance*. The Universities admit students on the basis of their own Matriculation Examination but for many years past passes in the Leaving Certificate Examination in matriculation subjects have been accepted in lieu of the Universities' own examination, hence the University influence on the Secondary school curriculum; an influence that has been pronounced and lasting. The Universities are consulted on the matter of Leaving Certificate Examination papers in matriculation subjects a practice which in turn seriously affects the nature of the work in Secondary schools. The University influence over the years has become more pronounced as criteria for university entrance became more rigorous.

The attempted reorganization of all of post-primary education on comprehensive lines begun in 1963 has precipitated a number of major changes in the curriculum. The Government plan was (and still is) to implement comprehensive education by facilitating and promoting co-operation between all post-primary schools in a given area leading to the effective sharing of resources. Steps were taken to enhance the status of Vocational schools. The Common Intermediate Certificate Examination was available from 1968 based on a common syllabus in Secondary and Vocational schools. The dead-end nature of vocational education was removed in 1969 when the course was extended with the inclusion of a senior cycle. Thus students from Vocational schools could sit for the Leaving Certificate Examination which now included a wider range of subjects many of them technical in nature such as Building Construction, Art, Mechanical Drawing. A review committee in 1967 recommended that the Leaving Certificate be taken at 17+ and an Advanced Certificate after a further year. The committee also advocated the organization of the curriculum into cognate subject groups viz. Language, Commerce, Science, Technical Studies and Social Studies groups. However this departure was opposed by the Universities and the Secondary school authorities and consequently subject grouping remains permanently optional though promoted by the Department of Education. The idea of an advanced certificate has been dropped.

The effect of the Government's programme of comprehensivization is most pronounced on the vocational sector. Until recent years there was a marked difference between the Secondary and Vocational school curriculum. The Vocational schools' programme was largely technical in nature and full-time education in this sector ended after three years. It was not until 1966 with the introduction of the Common Intermediate Certificate that pupils from Vocational schools were admitted to the Intermediate Certificate. Prior to that time the only examinations in the vocational sector were the Day Group Certificate taken after completion of the full-time day continuation course and the certificate examinations of the Department of Education in trade and technical subjects. The former came to be recognized as the educational standard for entrance to apprenticeship and the latter were graded examinations usually attempted after part-time study in technical schools. The 1963 Government plan for post-primary education announced by the Minister for Education, Dr. Hillery, was aimed at blurring the boundaries between the Vocational and Secondary school systems by enhancing the status of Vocational education. The introduction of the Common Intermediate Certificate Examination was effected by widening the examination curriculum to include practical subjects. A Technical Leaving Certificate, with parity of esteem with the Leaving Certificate, was envisaged for an extended full-time course in vocational education completed in large technical schools and the new Regional Technical Colleges. The Regional Technical Colleges materialized in 1969 and subsequently but a Technical Leaving Certificate was never introduced. The emphasis of shared facilities and a reinterpretation of comprehensive education in the Irish context led to the introduction of senior-cycle courses in the vocational sector in 1969. The examination curriculum for the Leaving Certificate examination has been widened to include technical subjects. The effect of these examinations arrangements on the vocational system appears to be leading to a marked emphasis on academic studies rather than technical studies. The reasons for this are twofold, the core subjects for this examination are in the traditional areas and vocational schools must opt for them, and secondly the possibility of university entrance from the vocational sector has provoked university interest in the system for the first time since the founding of the system. Their matriculation requirements remained in the traditional subjects and only very recently have technical subjects such as studied in Vocational schools been added to the list of matriculation subjects. The general tendency in post-primary education therefore, is towards provision of a uniform but wider curriculum for all schools on comprehensive lines, however, the traditional bias towards academic subjects has proved extremely difficult to overcome and to be such a force in Irish education as to seriously slow down an effective com - prehensivization of Irish post-primary education.

It is an unmistak able fact of life in Irish post-primary education that the examination system stands out as *the single most important factor influencing the curriculum*. However the central agency administering the examination system namely the Department of Education has shown signs in recent years of bending more to the wishes of professional educationalists in matters affecting the curriculum and education generally. The subject syllabuses were extensively revised in the sixties including the introduction of the new mathematics programmes. The world-wide trend towards integrated science has influenced the general science curriculum at Intermediate Certificate level and experimental combined Physics-Chemistry syllabuses were made available at Leaving Certificate level. Curriculum projects once unknown in Irish education are not uncommon and even the examination system itself has come under scrutiny. The ICE report in 1975 proposed a system of school-based assessment in place of the Intermediate Certificate Examination and a project set-up under the auspices of that committee i.e. Public Examination Evaluation Project

(P.E.E.P.) based at Trinity College has been instrumental in causing changes in the format of the public examinations. Currently public examinations are graded on a five-point scale replacing the old system of marks which operated since the introduction of the original programme in 1924. All this activity indicates at least the beginnings of a rational and professional approach to education in Ireland, a development which has been long awaited and is now urgently needed.

CHAPTER V

TEACHER EDUCATION AND TRAINING[1] IN IRELAND

A detailed description of the Irish education system highlighting important influences and trends together with their historical antecedents and current manifestations is contained in the previous chapters. Such a presentation and analysis was deemed necessary because it was seen as an essential prelude to any significant study whose central consideration is embedded in the Irish education system even if the ultimate goal is to transcend the local or national picture. Every real educational experiment is conducted in a given system of education be it local, state or national, and is therefore constrained by circumstances and institutions which are an inheritance from the past. Further, this inheritance may have the effect of involving us conceptually and habitually in a set way, and unless sufficient information is provided as a basis for an adequate evaluation of this inherent bias the value of the research to a wider community of educationalists is greatly reduced. Separate starting points usually visible in terms of different institutions, different legislative bases and practice are inevitable but in need of explication. Such things are normally explicable only in terms of earlier history, in this case the earlier history of the Irish education system.

---

1. Throughout the chapter and the thesis generally the preparation of teachers is variously called 'education' or 'training'. These are simply labels and are not meant to be descriptive of the process involved. Where description is intended the text will be more explicit.

And so it is with teacher education the central concern of this chapter. In this regard current practices, procedures and regulations are intelligible only against a backdrop of history specifically the history of teacher education in Ireland, an adequate grasp of which demands the wider perspective afforded by the history of Irish education. Thus the potential power of the earlier chapters is realized in this and subsequent chapters. Failure to identify the principal motives, political and educational, and the formative influences which shaped the system of teacher education in Ireland must be considered less than adequate in the circumstances. It is such considerations which force one to hark back to the history of the Irish education system, a history which is summarized in preceding chapters in such a way as to facilitate inevitable historical excursions such as establishing the genesis of teacher education as an organized, well-defined activity in Ireland. Consequently these activities are less laborious and time-consuming but none of the requisite clarity is lost in the process.

Candidates come to teaching in Ireland to-day by a variety of well-worn routes, many of them in their essentials firmly established before the founding of the modern Irish State. These arrangements are directly related to the prior history of the various educational sectors and the nature and conceptions of education evolved in Ireland. Separate unco-ordinated independent sectors of the school system gave rise to separate arrangements for the training of teachers for each sector. Nowadays, National (primary) teachers are educated and trained in Colleges of Education, Secondary teachers for the most part are university graduates while Vocational teachers are still recruited from a variety of sources but mainly from the ranks of university graduates. Once again the most expedient way to proceed is with reference to the traditional demarcation lines in Irish education and examine teacher education as it pertains to the various sectors namely, Primary, Secondary and Vocational education.

1. <u>The Kildare Place Society and Teacher Training</u>

Popular elementary education was widespread in Ireland at the beginning of the nineteenth century but the quality of the instruction was extremely variable. Hardly any system of teacher training existed and consequently the majority of teachers were ill-prepared and less than adequately qualified for the task [72]. By and large schoolmasters were the products of the elementary school system they were perpetuating.

The widespread availability of elementary education during this period was due in large measure to the efforts of the Kildare Place Society, a voluntary organization in receipt of State monies, which founded, supported and controlled a large system of elementary schools throughout the country. The extension of elementary education to a significant proportion of the populace inevitably drew attention to the supply and quality of teachers. Already the poor quality and ignorance of schoolmasters was referred to in the report of a Royal Commission in 1806 which recommended training for elementary teachers [72]. The Kildare Place Society early recognized the need for training and instituted a system of training for its teachers in 1814. *This undertaking represents the first organized and systematic attempt at teacher training in Ireland* [73].

The evolution of teacher training in Ireland stretches back in a direct unbroken line to the system of training instituted by the Kildare Place Society and therein lies its importance. The line of succession is clearly visible even today in Irish educational history. The trace links the present Colleges of Education to the Training Colleges and those in turn to the Kildare Place Society through the Commissioners of National Education. The Colleges of Education are essentially updated Training Colleges which were the gradual outgrowth of the system of training adopted by the Commissioners of National Education after 1831. But the Commissioners borrowed heavily from the Kildare Place Society which they replaced. In organization and inspection the system of national education followed the Kildare Place Society's schools and their textbooks were widely used by the Commissioners until they were replaced by the Commissioners' own series of text books. It is not surprising therefore to learn that the Commissioners modelled their system of teacher training on the system already in vogue. The Kildare Place Society system of teacher training became the prototype and in a sense dictated the pattern of teacher training for many years to come [73].

The system of training introduced by the Kildare Place Society reflected that Society's desire to implement the Monitorial System in its elementary schools. Lancaster's system which provided for *undenominational* religious education was imported from England. The system was cheap and efficient and as such was very attractive to a voluntary education society with limited financial resources [73]. John Veevers, Lancaster's protegee, brought the system to Ireland and stayed to become the first superintendent of Kildare Place Model and

Training Schools in 1819. Veevers, true to his master, developed an undenominational system of teacher training based solely on the monitorial system. Trainee teachers were allowed to observe the best in practice in the Society's model school and their *training* consisted solely and exclusively of observing and practising the monitorial system under supervision. The course of training was *short* and *intensive* initially 4-6 weeks duration but later extended to two months. From 1818 young men in training were required to *reside together* thereby increasing the benefits of training - or so it was thought at the time. The success of the course led to a surplus of applicants and inevitably *entry qualifications* were demanded. Upon completion of the course candidates were *examined* by Veevers and if successful awarded a *certificate*. The salient features of the Kildare Place Society's system of training were (1) it was undenominational; (2) it demanded entry qualifications; (3) was short and intensive; (4) was residential; (5) culminated in an examination which was qualificatory for the award of a certificate. Thus the pattern of teacher training in Ireland in the early nineteenth century resembled closely the practice in England during the same period.

2. The Board of National Education Commissioners and Teacher Training

The advent of the system of national education in Ireland precipitated the decline of the Kildare Place Society's direct influence in Irish elementary education. And from 1831 elementary education became increasingly the preserve of the Board of National Education Commissioners. Starved of Government monies a voluntary philantrophic education society could not compete with a State-supported system. The Commissioners were aware from the beginning that they had responsibilities in the area of teacher training. The Commission of Inquiry in 1828 pointed out that one of the principal functions of a board of education in Ireland must be to increase the supply of trained teachers. Accordingly, when Stanley established the system of national education he charged the Board with responsibility for the training of teachers. Specifically Stanley's letter stated that the Board would be responsible for a Model School in Dublin and the training of teachers for country schools [10]. A novel, if at the time unrealistic, feature of Stanley's instructions in this regard was that all teachers were to be trained *before* they took-up appointments as school-masters in the Board's schools.

The National Board adopted the Kildare Place Society's model for teacher training. From the outset in 1834 the Board's training was undenominational and based on practice in the Monitorial system obtained in the Board's own model school(s) maintained specifically for that purpose. As soon as the Board acquired suitable premises at Marlborough Street in Dublin in 1838 training became residential. The training course was short, initially of three months duration but later extended to five months, and five months remained the length of a typical course for many years. The Board consolidated its operations at Marlborough Street where it developed an educational complex which included the Central Model Schools and the training department established in 1838 [74]. This central training institution subsequently became known as the Marlborough Street Training College and it figured in Irish educational history until its closure in 1922. The

Board following the example shown by the Kildare Place Society as early as 1824, itself admitted women to training in 1842 having opened in that year a residence, Tyrone House, for women teachers. Early in its history the Board showed concern that the training course at the central training establishment be extended to two years so that time could be devoted to *educating* and *training* candidates. However, the course remained short and intensive for many years and was primarily a course of training in the art of teaching.

The Board was confronted by a problem of massive proportions in the area of teacher training. The enormity of the task can be gauged from some educational statistics of the day. There existed in Ireland in 1832 an estimated 9 000 pay schools and 2 000 other elementary schools including 1 621 schools founded or assisted by the Kildare Place Society [75]. The majority of pay schools eventually came under the aegis of the National Board. The Kildare Place Society had during its time trained approximately 2 500 teachers [75]. It is clear from these figures that the majority of school-masters were untrained. And they were *already* in charge of schools. They were for the most part products of the pay schools and as such their educational attainments were scarcely better than the then elementary education of the schools. In the circumstances the Board's original objective of training teachers prior to service was hopelessly out of reach and the more limited aim of arranging *some* training for teachers in service was to prove exceedingly difficult. In the event, the training course at Marlborough Street became a course of training for teachers already in service and was not therefore, a pre-service course. It was short and intensive and as such was designed to extend the benefits of training to as many teachers as possible [73]. The rationale behind the short course was simple, some training could be imparted to more teachers quickly if the course were of short duration allowing two or more classes per year to pass through the training institution. However, the problem was accentuated by its non-static nature. With the expansion of the national system of education inevitably the demand for teachers grew, thus placing a greater strain on the training establishment. The problem was exac erbated by the absence of an adequate supply of suitably qualified candidates for training since the majority of Irish people at the time received no more than an elementary education in an ordinary national school. It soon became apparent to the Commissioners on the Board that the national system of education, in the absence of a generally available secondary education, would have *to serve as its own source of supply of national teachers.*

The Board introduced various schemes for improving the quality of teaching in its schools. The upgrading of the credentials of the existing teaching force was an immediate identifiable task and the Marlborough Street Training College was an appropriate response. However the Commissioners were aware that the College was not equal to the task due mainly to the paucity of places for candidates in training. The Board resolved to reach untrained teachers in the schools by introducing a system of classification for all teachers in conjunction with the efforts of the Training College. A system of classification introduced in 1839 was designed to provide an incentive for practising teachers to improve themselves academically. In the event, the Board had accurately identified the lack of remuneration for elementary teachers - a consequence of the low esteem in which teachers were held in Ireland and in Europe generally - as an outstanding defect in the national system of education [73]. The Commissioners attempted to remedy that problem and the related problem of lack of incentive to improve by introducing a system of grades with differential salaries. Teachers were classed in three categories - 3rd class, 2nd class, 1st class - by the Board's inspectors and paid accordingly. New teachers were placed in a probationery class for one year. All teachers were classed by the inspectors before they went to Marlborough Street and were re-classed at the end of their course of training by the teaching staff at the Training institution. The classification lasted for three years and was not confined to upward mobility only. Initial classification and subsequent promotion/demotion depended upon the 'efficiency and literary merit' of the individual teacher as judged subjectively by an examining inspector. The major drawback in this system viz. subjective classification by inspectors was removed in 1848 when teachers were classified on the basis of a written examination. The new system subdivided the three classes into divisions - First Class was divided into three grades, Second and Third into two grades each. Examinations for each division were set, administered and marked by the Board's corps of inspectors. This system of classification survived without substantative changes until it was replaced by the 'payment by results' system introduced after the Powis Commission's Report.

The spread of universal primary education in Ireland in the first half of the nineteenth century highlighted the shortage of qualified teachers. The problem of providing and maintaining an adequate supply of suitably qualified candidate teachers for the primary schools was a problem which the Board had in common with other European countries. The monitorial system was a temporary expedient adopted in many European countries notably England and Holland. However, by mid-century it had been replaced generally by a system of licensing of teachers or by employment of pupil-teachers [43]. Pupil-teachers were introduced in England in 1846 by which time they had been successfully employed for many years in Holland where the idea seems to have originated. In Ireland, the monitorial system proved more durable than in other countries. Far from being a temporary expedient it survived well into the twentieth century and proved to be one of the principal institutions of the Board [73].

The Board relied mainly on the monitorial system for its supply of new teachers. In this way the national schools were able to generate a *source* of supply of new teachers which alleviated the recruitment problem which hinged on the availability of a secondary education. Secondary education was not generally available in Ireland during the nineteenth century, consequently the Board was forced to fall back on the monitorial (or some such) system. In practice pupil-monitors were used in the national schools but upon completion of their own education were too young to enter the training college or become a national teacher and were still in need of some further education viz. secondary education. An attempt to bridge the gap between the end of primary school and entrance to Marlborough Street or first employment as a school-master was made in 1846. The Board instituted a system of paid monitors whereby selected pupils in national schools were retained to assist in the schools. These brighter pupils were expected to teach for three hours per day and spend another two hours on personal study supervised by the school master. In return for their services they were paid a small salary by the Board. Paid monitors were examined each year by the Board's inspectors and expected to pass a set examination. Monitors could be retained in this way for a period of up to four years by which time, given that they had passed each year's examination, they were sufficiently qualified to enter the Training College. However, due to the demand for teachers and the shortage of training places at Marlborough Street, many of these monitors went directly into teaching.

Concom itant efforts by the Board to come to grips with the problems occasioned in teacher training by the absence of further educational facilities for national school pupils led to the establishment of district model schools. An elaborate network of such schools, founded and controlled by the Board, was envisaged and eventually thirty model schools were built throughout the country departing somewhat in the process from the projected pattern of one to each of the thirty-two counties in Ireland. The principal purpose of these schools was to provide a supply of well-prepared candidates for Marlborough Street but in practice they also provided preliminary teacher training for paid monitors and pupil-teachers many of whom never proceeded to training college. Pupil teachers, first appointed in 1846, were selected from the paid monitors in a district by the district inspector and sent for preliminary teacher training and further education to the district model school as a prelude to entry to the central training establishment. The progression to the training college was by way of practical experience or apprenticeship - one progressed from paid monitor to pupil-teacher and after six months in the district model school spent two years in a national school before going to the training college to complete training[73]. It should be noted that the model schools were elementary schools and not secondary schools and as such relied heavily on the monitorial system. Trainee teachers received their further education from the elementary school-master to whom they were for all intents and purposes apprenticed and not in the ordinary classes conducted in the model schools [73].

The Commissioners of National Education were determined to resolve the problems of supply, recruitment and training of teachers by recourse to the monitorial system. An elaborate system evolved under the Board of Commissioners which integrated the central training institution and its model schools and the district model schools together with a system of paid monitors and pupil-teachers. Circumstances dictated that progress be made on several fronts simultaneously and advances were made. The proportion of untrained teachers in the system decreased and in 1851 approximately 40 percent of teachers were trained. The situation had improved somewhat by 1857 when 48 per cent of teachers in the system were trained. In 1868 approximately 45 per cent of teachers were trained. By 1873 the proportion of untrained teachers had increased again so that only one-third of all teachers were actually trained [73]. The reverses suffered by the Board were due mainly to Church opposition to its activities in teacher training, an important episode in the history of teacher training in Ireland. The nature and extent of the Board's response to contemporaneous problems in teacher training are perhaps best illustrated by outlining the Board's own promotional ladder as it existed by mid-century. The whole system was articulated so that a national school pupil with sufficient ability and motivation could progress from pupil to paid monitor to pupil-teacher and then serve a spell as a teacher in a national school before completing his training at Marlborough Street Training College.

At the Training College candidates were accepted into the general class but from 1845 onwards a number of better students from each class formed a special class which was given further training - itself a year course by 1855. This elite was much sought after and the Board itself employed them as teachers in the district model schools. The idea of an extended training course at the training college was favoured by the Board but could not be implemented generally for practical reasons. However, the rationale behind the special course and an extended training namely, providing an opportunity for *education* as well as *training* proved to be the main characteristic which distinguished the Board's activities in teacher training from those of the Kildare Place Society. The Board pursued its objective of educating as well as training by appointing professors at the Training College. Only two professors were appointed and these in 1838 although the Board proposed initially to establish five professorships. Nevertheless the ideal was actively nurtured, if only minimally provided for in practice.

Because of the poor quality of the intake - the general stock of teachers being very ignorant with many unable to teach reading and writing - initially the training course was confined to the bare essentials [72]. Masters were selected indiscriminately by the Board's inspectors no other qualifications being necessary except that the candidate be a school-master and under twenty five years of age [73]. The Board's aim was to spread the effects of training, if only rudimentary in nature, throughout the system without delay by training as many as possible as quickly as possible. The first class entered training in 1834 and was instructed in English grammar, elements of Mathematics and required to study the Board's lesson books. Much of the time was given over to observing and practicing the monitorial system in a model school. The Board's policy was to ensure that trained teachers were conversant with the Board's textbooks and these lesson books were used as the focal point of the training course. The training consisted simply of ensuring that teachers were able to answer questions arising out of the Board's lesson books and practice in the monitorial system of instruction [72]. A course of lectures based mainly on the lesson books was delivered by the head of the model school and trainees were expected to master the lesson books after reading assigned pages and answering any questions arising. The course was extended from three to four months and finally settled at five months in 1843 and remained fixed at that figure until 1883. The actual course continued to revolve about the lesson books while the training for women teachers was confined largely to domestic training. In due course the entry requirements were stiffened. An entrance examination was introduced in 1843 and candidates for training were expected to have a satisfactory knowledge of Arithmetic, Geometry and Mensuration, and of the Board's third, fourth and fifth lesson books which contained information of a general nature including historical and scientific knowledge [73]. In addition candidates were required to produce a certificate of good character, and until discontinued in 1843 swear an oath of allegience before a magistrate. The intellectual requirements for admission to training gradually grew more rigourous and by 1870 each candidate had to be able to read and write, pass examinations in Grammar, Arithmetic, Algebra, Geometry, Mensuration, Geography and Book-keeping, some concessions being made for women candidates [73]. The major criticism of this training under the Board's aegis was that it was mechanical. For example arithmetic was taught so that children might be mechanically dexterous doing simple computations [72]. Despite the aspirations of the Board the training course was narrow and mechanical and in no sense educational - it was post-elementary, maybe intermediate but certainly not close to university standard.

3. The Growth of the Training Colleges

The severe attack by the Powis Commission (1868-70) on the Board's teacher training arrangements was hardly warranted on educational grounds alone. The attack might have been politically motivated. The Board's activities in teacher training had aroused the opposition of the Catholic Hierarchy a powerful political force in Ireland by the 1850s. By 1860 the Church had made *control* the major issue in teacher training [73]. She was particularly opposed to *Government control* of teacher training which was essentially the case in Ireland as long as the Board, a government agency held the reins. The Church found the district model schools especially disturbing as the ideal of *undenominational* teacher training was being pursued diligently in these schools which were under the direct control of the Board. In 1863 the Church implemented a total ban on model schools and the central training establishment at Marlborough Street. This action followed an earlier declaration of the bishops in favour of denominational education which emanated from the Synod of Thurles in 1850. By mid-century the Church felt sufficiently strong *politically* to challenge the British Government on the issue of the Board's undenominational education and actively and successfully campaigned for denominational education. In practice the Church succeeded in converting the avowedly undenominational national system to a denominational one and was satisfied with the measure of control she had won over the system. However, the Church was dissatisfied with the system of undenominational teacher training sponsored by the Board. The hierarchy pressed for voluntary training institutions in Ireland established on the same basis as those which operated in England at that time. Voluntary training institutions in Ireland meant denominational institutions in practice as only the Church was in a position to found and support such establishments. By keeping to its ban on the model schools and Marlborough Street Training College the Church was responsible for a widening of the gap between the numbers of trained and untrained teachers in the system since school managers were forbidden to hire teachers trained in model schools or at Marlborough Street [73]. The issue was resolved when the Powis Commission severely criticised the Board's provisions for teacher training and recommended voluntary training institutions for Ireland. The Government conceded the principle of denominational teacher training for Ireland an *control passed from State to the Church when the denominational training colleges were recognized after 1883.*

Despite the recommendations of the Powis Commission denominational training colleges were not sanctioned by the Government until 1883. In that year the National Board was authorised to make grants to voluntary training establishments on terms similar to the system in operation in England. Private colleges were paid grants on a 'Credit System' - male students who passed probation and received a diploma earned fifty pounds for each year of the two-year course, the sum was thirty five pounds for women [72]. In this way the State met 75 per cent of certified expenditure on rent, rates, and loan interest charges and operating costs. The management of these private colleges was in the hands of the bishops who as promoters were required to provide buildings and equipment. St Patrick's Training College, Drumcondra for Catholic men, first opened in 1875 and handed over to the Vincentians in 1883 was recognised by the Board in that year. Our Lady of Mercy, Baggot Street, also in Dublin but established for the training of women teachers was also recognized by the Commissioners in 1883. Although in the hands of religious - Vincentian Priests and Mercy Nuns respectively - management was nevertheless vested in the bishop i.e. the Archbishop of Dublin. The Church of Ireland Training College at Kildare Place for Protestant men and women was aided by the Board from 1884 and under the management of the Anglican Bishop of Dublin. Inherited from the Kildare Place Society this training college was continued by the Church Education Society, a voluntary Anglican society, until the college was taken over by the Board of Education of the General Synod of the Anglican Church in 1878. These denominational Training Colleges operated side by side with the undenominational Marlborough Street Training College whose total financial liabilities were underwritten by the State.

The method of financing the private Training Colleges was reviewed in 1890 at which time the 'Credit System' was abolished altogether and replaced by a system of grants based on a fixed capitation basis known as the 'Balfour System' [74]. Subsequently three new private Training Colleges were opened, one for Catholic men - De La Salle College, Waterford in 1891; and two for Catholic women - St. Mary's College, Belfast in 1900 and from 1901, Mary Immaculate College, Limerick. Thus in September 1922 and the advent of independent Irish Government, there were seven Training Colleges in Ireland in receipt of State aid via the Commissioners of National Education with a total of 545 licensed places for men and 650 places for women [74].

The advent of the Training Colleges in 1883 meant an end to the short intensive training course pioneered in Ireland by the Kildare Place Society and continued by the Commissioners of National Education. From 1883 all candidates with the exception of certificated teachers had to undertake a two year course of training. Certificated teachers i.e.serving teachers were obliged to undergo a one year course of training at a Training College. The course evolved under the Board's administration from a three months course concerned exclusively with training in school organization and instruction and practice in a practical method of instructing pupils i.e. the monitorial system. The emphasis was on training teachers how to teach the elementary school subjects in the Board's curriculum for national schools. The course was extended to five months in 1843 and later to ten months in 1874 and finally to two years in 1884. These extensions were necessitated by the obvious need to *teach* the candidates what they were supposed to know i.e. the school subjects as well as training them in the art of teaching. From the beginning the course of study in the Board's Training College encompassed a uniform course which included English, Mathematics, Principles and

Practice of Education, and History and Geography. Women studied Arithmetic only but their training always included needlework while the men read a course in agriculture. "The course usually made heavy demands upon the students memory and did not produce general cultural results of great value" [74] (p.38). The Board's course set the pattern for all the Training Colleges until the end of the nineteenth century. Coverage and treatment of topics was lacking in breadth and depth since students' studies were confined to the Board's manuals. A wider and more liberal course was introduced after 1900 and this revised course remained in operation until the reform effected by the Department of Education in 1923 after independence. From 1900 certificants from the Training Colleges were obliged to complete two years on probation before the award of a diploma which signified the successful completion of training [72].

4. The Training Colleges in the Republic of Ireland

Some important administrative reforms in the system of teacher training were effected during the transition period from British to Irish government and in the years immediately after. Marlborough Street Training College was closed from September 1922 and St Mary's Training College, Belfast passed out of the jurisdiction of the Free State in 1923 leaving the Department of Education with control over five colleges viz.

		Men	Women
St Patrick's (Dublin)	licensed for	165	-
Our Lady of Mercy (Dublin)	licensed for	-	200
Church of Ireland (Dublin)	licensed for	50	85
De La Salle (Waterford)	licensed for	200	-
Mary Immaculate (Limerick)	licensed for	-	100

Among other things, the matter of supply and recruitment of national teachers required attention. The source of supply was a matter causing immediate concern to the officials of the new department as several of the Training Colleges were unable to fill their quota of places owing to a shortage of qualified candidates [74]. All candidates with the exception of graduates who might be exempted were expected to pass an entrance examination held at Easter. The examination was competitive but places were reserved for different categories of entrants. In 1924 candidates for training were drawn from the ranks of untrained teachers, monitors, pupil-teachers, and private students. In subsequent years the monitorial system was abandoned and a reorganized recruitment system was based on pupil-teachers and pupils from the new Preparatory Colleges as well as other traditional sources. Candidates for training were drawn in order of priority from (a) Preparatory Colleges (b) Pupil-teachers (c) Untrained teachers (d) Easter Scholarship Examination. A quota system based on a priority ranking remained in existence for many years, the main avenues being (a), (c) and (d) after the pupil-teacher system was discontinued in 1938.

As indicated earlier the Board relied mainly on the monitorial system and associated schemes for its supply of teachers. By

1924/25 the system was definitely unable to supply the demand despite the various reorganizations which were effected by the Board of National Education in the latter half of the nineteenth century. The reorganizations, however, left the system unchanged in its essentials. The mainstay of the supply and recruitment system was monitors and pupil-teachers. The Board's final reorganization of the scheme in 1905 improved the system generally by raising the minimum age of entry from thirteen to fifteen for monitors and strengthening their practical training. The duration of the course was generally fixed at three years [74]. Meanwhile efforts were made to improve the pupil-teacher scheme by offering pupil-teacherships to pupils who had obtained passes with honours in the Intermediate Examinations. Nevertheless the monitorial system was a failure, failing to supply an adequate number of qualified candidates for the Training Colleges. The failure was due mainly to the fact that *the system did not provide adequately for the general education of the monitors* who were therefore unable to compete with secondary school pupils for places at the Training Colleges. The system of paid monitors, was abandoned in 1926. A new system of pupil-teachers was instituted requiring selected pupils to complete the two year Leaving Certificate course before entry to the Training Colleges. In order to improve the recruitment situation further the Government established Preparatory

Colleges[1] for intending teachers. These were new residential secondary schools designed to provide a general secondary education to Leaving Certificate standard for clever pupils selected by open competition who wanted to become primary teachers. The Preparatory Colleges - seven in all were founded after 1926 - supplied candidates for the Training Colleges who were fluent in Irish. The Training Colleges reserved places for such candidates as part of the Government's design to increase the stock of primary teachers in the system who were competent to advance the Irish revival in the schools. The Government's preoccupation with Irish language qualifications of the teaching force combined with the effort and resources devoted to raising such qualifications was never adequately justified on educational grounds. The Preparatory Colleges continued in existence until the sixties when the wisdom of selecting future teachers at such a young age and cloistering them away together in Preparatory Colleges was

---

1. The Government's scheme provided for the establishment of seven Preparatory Colleges, three for Catholic boys, three for Catholic girls, and one for Protestant pupils. Except for the Dublin Colleges the Preparatory Colleges were located in native-speaking areas. The Colleges were Colaiste Einde (Galway), Colaiste Caoimhin (Dublin), Colaiste Iosagain (Ballyvourney, Co Cork),Colaiste Brighde (Donegal), Colaiste Ide (Dingle, Co Kerry), Colaiste Moibhi (Dublin) and Colaiste Muire (Tourmakeady). Recruitment to Training Colleges from the Preparatory Colleges ceased in 1964 except for the Protestant College. All recruitment was discontinued by 1967 and the remaining College was closed in 1968.

questioned and ultimately the practice was discontinued. The pupil-teacher scheme was abandoned altogether in 1938 in a time of reductions in the teaching force, its fate having been sealed by a more generally accessible secondary education.

After independence the management of the Training Colleges remained in ecclesiastical hands. Nothing was done by the new administration to disrupt Church control in any sphere of education in Ireland, least of all teacher training. However, the Training Colleges as they were perpetuated were less than fully autonomous institutions and were closely supervised by the new Department of Education. The Minister for Education reserved to himself certain important matters of administration including selection of students and numbers admitted in any year, appointment and conditions of service of professional staff, and certain other matters including the amount of student fee. The Colleges continued to be State-aided, residential and fee-charging institutions. However, the State provided no scholarship aid for the Training Colleges but instead aided students by making repayable loans to students via the Department of Education to defray the costs of training. Teachers undertook by way of formal agreement to serve for five years upon completion of training and loans made by the Department were repaid during this period by regular deductions from salary. It is noteworthy that no other teachers in training, with the exception of specialist teachers trained by the Department, were favoured with such financial arrangements. The Department of Education influenced the actual work in the Training Colleges by setting the tenor of the courses and giving direction as to the relative emphasis between professional courses and academic courses [76]. The Colleges' professors conducted the first year qualificatory examination while the final examination was conducted by the professors by arrangement with the Department of Education. Allowing for evolution of the system no fundamental changes occurred in the system of teacher training until the seventies.

Since the general standard of education of candidates for training was lacking - invariably entrants to the Training Colleges had completed elementary education only - the new Administration devoted considerable energy to developing a system of supply and recruitment which guaranteed a higher standard of general education. In an age when preliminary training for prospective teachers was still valued and advocated in Ireland the Government's aim was to ensure that every prospective teacher completed the full available course of secondary education [72]. The Irish Government's aim was in keeping with the pattern of teacher training in European countries generally many of which demanded completion of the full course of secondary education as a minimum entry requirement. In Ireland the Monitorial System was discontinued in 1926 precisely because paid monitors could not compete with pupils from the secondary schools. The system of pupil-teachers was remodelled to ensure that each pupil-teacher attained a standard of general education equal to a general secondary education. Inevitably the consequences of these reforms were felt in the Training Colleges. Specifically new entry requirements were established and in the school year 1932/33 a new programme of training was initiated in the Training Colleges. In the previous year a new system of examination for candidates in the open competition was introduced. Unlike entry in previous years which was based on passes in oral and written examinations in a wide range of subjects, the new system relied on the results of oral examinations at Easter in Irish, English and Music and a practical test in Needlework for girls combined with the examinees' performance on the Leaving Certificate in the following summer. Candidates for training were selected in order of merit on the combined results of the two examinations [77]. And so the Leaving Certificate became part of the selection procedure for entry to the Training Colleges. It remains so even today when the method of entry and admission requirements are substantially the same. Candidates must be aged between 17-21 years, have a good Leaving Certificate and perform satisfactorily in preliminary tests in oral Irish and English, Singing and Needlework for girls. In recent years the interview has gained increasing significance as a means of determining the candidates suitability for the teaching profession. The College and the Department of Education are represented on the interview panel.

The emphasis on the Leaving Certificate as a minimum entry requirement led to changes in the Training Colleges' programme after its introduction in 1931. The better general education of candidates for training led to a substantially revised programme in the Colleges after the school year 1931/32. The emphasis on general studies was lessened and more time was devoted to practical training. The educational work in the Colleges was altered and "confined to such an amount as might be needed to foster the habit of study in the direction of the students' natural aptitude" [76] (p.14). The course of training remained biased towards the vocational or professional aspect of the teacher's formation and only recently was there any appreciable movement towards catering adequately for the personal education of future teachers while in training.

After 1923 the two-year course at the Training Colleges encompassed Irish, Mathematics, Practice of Teaching, Education, Drawing, Rural Science, Music and Physical Training with Needlework and Domestic Economy for women. History and Geography were taken by first year students and all candidates were examined at the end of each year of study and if successful in the second year examination they were eligible for appointment to a primary school as a trained teacher. However, no final diploma was awarded them until after the satisfactory completion of two years continuous service in a national school [74]. During the 1930s the actual work in the Training Colleges was organized into two sections (1) Principles and Practice of Teaching; (2) Subjects and elements of school work which required more detailed treatment in light of experience or because they were not previously studied [72]. The first year was devoted to topics in Education which guided students on their first teaching practice. The second year was spent reviewing the first year in view of the students' experiences, and completing topics begun in the first year. The principal innovation in the course was the provision made for the practice teaching to take place in ordinary national schools and not as heretofore in the Practice school(s) associated with a Training College [76]. Irish became the medium of instruction in all the Training Colleges with the exception of the Church of Ireland Training College and the pattern of training remained about the same until the seventies, despite a reorganization of the colleges' syllabus into three sections in the 1950s. In the sixties the training course was still two years long and consisted of courses in the following subjects:- Irish, English, History, Geography, Principles of Education, Teaching Methods, Latin, Religion, Mathematics, Voice Training, Physical Education, Hygiene, Drawing and Painting, Science and Nature Study, and Instrumental Music [17]. The colleges continued to require students to board at the college and the colleges remained single-sex establishments catering for either men or women trainees but not both.

5. The Training Colleges and the University Link

The nature of the new programme introduced into the Training Colleges in the school year 1932/33 was influenced, among other things, by the desire "to provide for a standard of scholarship that would preserve for the students the advantages which they have so far enjoyed in relation to the University" [76] (p.14). The 'advantages' so called were almost negligible but nevertheless important to a body of teachers striving for professional recognition. By arrangement with the Senate of the National University of Ireland Training College students passing their final examination might qualify for exemption in the university First Arts Examination if they merited it after re-examination of scripts by university examiners. This exemption was never automatic since the University demanded passes in Irish, English and two subjects from Latin, History, Mathematics, Geography and French [78]. Having been exempted, the way was opened for progression to a B.A. degree in the normal way. By way of reciprocation university graduates could qualify as national teachers after an abbreviated course of training at the Training Colleges lasting one year. A limited number of places was reserved in the Training Colleges each year for university graduates and they ranked in order of priority for entry with untrained teachers. These arrangements were superseded in part when the Training Colleges were re-constituted as Colleges of Education in the 1970s.

Coordination between the Training Colleges and the Universities, limited though it was, existed since the 1890s. A university link was actively promoted at that time in order to improve the quality of the teaching force [72]. Various forms of association were promoted between individual Colleges and the Universities. For example, students from St Patrick's Training College attended lectures in Natural Philosophy at University College, Dublin. Trainee teachers from the Church of Ireland Training College attended lectures at Trinity College, Dublin during training and from 1919 could proceed to a B.A. by completing two further years at the University. This special arrangement lasted until very recent times with Church of Ireland students attending university lectures in general subjects as non-matriculated students of Trinity College. The various associations crystalized into two separate streams, the Church of Ireland Training College continued to enjoy special privileges at Trinity College while the Catholic Training Colleges generally became associated with the National University of Ireland enjoying whatever local arrangements were promoted from time to time, while training college students generally could avail of the exemption to First Arts Examination of the NUI.

What is interesting in these developments in view of the recent changes in teacher education and training in Ireland is the fact that students from the Training Colleges, King's Scholars as they were then known, presented for university examinations of the Royal University a purely examining body with no teaching functions. The Royal University was replaced in 1908 by the National University of Ireland,and indeed one of the reasons advanced for the founding of the NUI was the projected benefit to the teaching profession. From an early date then it is obvious that Irish elementary teachers were concerned with university recognition. As early as 1918 Chief Inspector T P O'Connor in evidence before the Vice-Regal Committee advocated a 'concurrent' teacher education programme allowing trainee teachers to proceed to a degree while they pursued their professional studies [72]. University education for all teachers was advocated by the Labour Party in 1925 in its policy statement on education contained in <u>Labour's Policy on Education</u> [79]. The case for a university degree for national teachers was taken up again by the Irish National Teachers' Organization in its important contribution to the educational debate in 1947, <u>A Plan for Education</u>[80]. The influential Commission on Higher Education which sat during the sixties supported this claim in its recommendations on higher education [81]. Again in 1970 the Higher Education Authority came out in favour of an extended course of training for national teachers culminating in the award of a degree. A reorganization of the Training Colleges broadly along the lines recommended followed the report of the Higher Education Authority in 1970. *The Government is now committed to the development of an all-graduate teaching profession an ideal which informs all recent reforms in teacher education and training in Ireland.*

6. The Colleges of Education

The decade from 1960-70 was a period of intense activity in Irish education. There were major reforms and innovations at second level but higher education generally also came under close scrutiny. The Commission on Higher Education sat and issued many volumes between 1960 and 1967. The Higher Education Authority came into existence in 1968 and there were the Minister's proposals for university reorganization in 1967. The Steering Committee on the Regional Colleges issued its report in 1967 and the National Council for Educational Awards was established on an ad hoc basis at the close of the decade. It would be surprising in such an era of investigation and reform if teacher education failed to receive attention. That it had failed to attract the notice of an investigating committee until the 1960s served as sufficient guarantee of attention then, belated though it was. The Higher Education Authority in 1969 was charged by the Minister with investigating the "question of the training of primary teachers in the context of the future provision for higher education" [2] (p.1).

The Authority availed of the opportunity to widen its brief and appointed a Working Party to investigate the problem of teacher education generally and not just primary teacher training. The Authority presented its findings to the Minister in July, 1970. The Higher Education Authority's Report on Teacher Education remains the most influential document on teacher education in Ireland.

The Higher Education Authority advanced five reasons for reviewing teacher education and training in Ireland at that time: (1) that no fundamental change had taken place in such training since 1922; (2) increased public awareness of the place of education in a rapidly changing society and the resulting demands on the educational system; (3) the introduction of new curricula at primary and secondary level; (4) the requirements of a modern technological society; (5) the projected increase in the numbers of primary and post-primary pupils and the ensuing demand for additional teachers [2]. In relation to the training of primary teachers the Authority's main recommendations were a reduction in the number of recognized Training Colleges in conjunction with the reconstitution of the three largest namely, St Patrick's College, Mary Immaculate College and Carysfort College, as Colleges of Education with a broadly based governing body for each College. Because of its special position the Church of Ireland Training College should continue to exist and provide denominational teacher training. The Colleges position as Colleges of Education would be based on an extended course of training of three years duration which would culminate in the award of a degree. Such an award could only be justified on the basis of a re-structured training programme with upgraded courses in professional and academic subjects. The Authority favoured co-education in the Colleges of

Education and an expansion of the number of non-residential students [2].

By 1974 the main recommendations of the Authority had been implemented. De La Salle Training College, Waterford closed in the interim and the Christian Brothers Training College[1] Marino and the remaining colleges were reconstituted as Colleges of Education. The movement toward co-education already begun continued and the numbers of non-residential students increased. In 1974 the course of training was extended to three years and each College of Education formally associated itself with a University College of Education for the purpose of degree validation. St Patrick's College of Education became a Recognized College of the National University of Ireland as did Our Lady of Mercy College of Education (Carysfort) and Mary Immaculate College of Education. The Colleges are associated respectively with University College, Dublin (two) and University College, Cork. Church of Ireland College of Education strengthened its traditional link with Trinity College, Dublin and its degree is validated by that University. The degree awarded in all cases is a classified B.Ed degree of the University.

The new link with the Universities is bound to affect the nature of the work in the Colleges of Education. It is too early yet to do anything but give a broad outline of how things are likely to be. However, some of the implications of degree status have already become obvious to the Colleges. The re-structured programme of

1. The Christian Brothers still train their novices at Marino to teach in their own schools. However, the College recently entered into an association with Trinity College, Dublin for the purposes of degree validation.

concurrent teacher education is now three years long and the bias towards professional studies has been moderated somewhat by University insistence on academic content. In general students are required to take Education and two other subjects[1]. In the Second and Third Years all students take Education and one of the other subjects taken in First Year. The Education Course may for descriptive purposes be considered under three headings: Theoretical Area, Professional Area and Practical Area which comprises the teaching practice experience [82]. While the new arrangements[2] are similar to the Colleges of Education in the U.K. in outline the details of validation, status of the Colleges in the University system and other details are quite different. The Recognized College status enjoyed by the Colleges of Education is the least influential in the hierarchy of the National University. Courses and course changes have to be approved in advance by the University and the University must sanction all staff appointments to the College of Education. In addition students must matriculate in the University as well as complying with the Minister's admission requirements.

---

1. In their First Year students at Mary Immaculate College take Education, Irish and two other subjects from: English, French, Geography, History, Mathematics, Music and Philosophy. Students at St Patrick's College take Education in their First Year and Mathematics, Music, French and Biology. All students in training follow a course of Religious Studies.

2. Some teacher training establishments remain outside these institutional arrangements. A small number of Montessori and Froebel teachers for primary schools have been trained at Maria Assumpta College, Sion Hill for many years. Such training continues in association with Trinity College Dublin.

The new link between the Colleges and the Universities forged in the seventies is a much more demanding one on the Colleges of Education than any previous association but the advantages are obviously great. If the enterprise proceeds as a cooperative effort then undoubtedly the benefits to both parties will be substantial.

7. Secondary Education and Teacher Qualifications

As already indicated (Chapter 11), Secondary Education in Ireland developed as a private enterprise prior to 1878. Consequently Secondary schools were private institutions, generally run on denominational lines by religious orders of Priests, Nuns or Brothers. During this period in the early history of the system the State was unwilling as a matter of policy to support denominational education at any level. The school managers were, therefore, unrestricted in their choice of teachers and whether the teachers hired were suitably qualified or not there was nothing the State could do under the existing conditions to influence the situation. Even when the State became involved in educational provision at intermediate (Secondary) level the relevant Act, the Intermediate Education Act, 1878, made no provision for the training of teachers. Under provisions in the Act, the State empowered the Intermediate Education Board to function as an examining body and to aid Intermediate education by payment of results fees. The nature of the Act and its provisions was due recognition of the private denominational character of secondary schools and the limitations such circumstances placed on State involvement. Clearly State interest at that time did not extend to regulation or supervision of the teaching force. For many years the State generally and the Intermediate Education Commissioners in particular, showed no concern with teacher qualifications [83]. In the absence of State regulation the quality of teaching was variable. Many teachers had no qualifications but some were university graduates. The prevailing opinion during this period and up to the end of the nineteenth century was that *a university degree was more than ample evidence of one's ability to teach* [72]. At the turn of the century 11.5 per cent of Catholic male teachers and 8 per cent of female teachers in intermediate schools were university graduates. The situation in this respect was far superior in Protestant schools where the teaching force included 56 per cent of men and 30 per cent of women who were graduates [67].

The establishment of the Department of Agriculture and Technical Instruction in 1900 was a significant event in the history of secondary education in Ireland. This Department under enlightened and progressive leadership succeeded in maintaining a particularly good record in the area of technical education. In its efforts to promote technical education of an acceptable standard the Department insisted on hiring appropriately qualified teachers [72]. From 1901 the Department insisted on minimum requirements from its teachers and in that year instituted a register for teachers in Science and Drawing and other technical subjects as a regulatory device [83]. A shortage of Science and Art teachers in Intermediate schools was occasioned at that time by the introduction of the Department's programmes into Intermediate Schools in 1902. By agreement with the Intermediate Education Commissioners, the Department's programme in Science and Drawing replaced the Intermediate programmes in Natural Philosophy, Chemistry and Drawing from 1902 [11]. To meet the shortage of teachers in those subjects the Department conducted special summer courses for teachers who were duly recognized as Science Teachers by the Department after attending five such courses and obtaining a special certificate [72]. The Department also recognized for teaching purposes, the Associateship of the Royal College of Science[1] conferred after four years study at that College's special Teacher's course run in association with the Department [72]. This concern with the qualifications of its teachers by the Department of Agriculture and Technical Instruction, a Government department *marks the beginning of State involvement in the training of teachers for secondary schools.*

The present Irish Government controls and supervises the qualifications of secondary teachers under provisions of a statutory instrument which dates from 1914. In that year a bill was passed, the Intermediate Education (Ireland) Act, enabling the setting up of a representative Registration Council. The Council was constituted in 1916 and regulations for a register of teachers framed by the Council were approved in 1918. The

1. The Royal College of Science founded in Dublin in 1867 was incorporated into University College Dublin under the provisions of the University Education (Agriculture and Dairy Science) Act, 1926.

Register for Intermediate Teachers has been effective since July 1918. As McElligott [17] (p.84) so aptly put it, "The aim and object of setting up a Register was to raise and secure the status of the profession of secondary teaching as an occupation for laymen and laywomen in Ireland". The Act also provided for the payment of a Teachers' Salaries Grant. The purpose of this Grant was to promote the employment of an adequate number of qualified *lay* teachers in intermediate schools [11]. The State was concerned at the time with a situation in Irish secondary schools which persisted for many years afterwards, a situation which operated against the recruitment of lay teachers due to a preponderance of religious teachers. The Register has operated without interruption since its introduction and has been the principal means of Government control of teacher training for secondary schools in modern Ireland. Since the mid-twenties only changes in the Register approved by the Minister for Education under the terms of the Registration Council (Constitution and Procedure) Rules, 1926 can be introduced [83]. At present the Register is administered by the Department of Education under regulations made by the Registration Council but previously approved by the Minister. The Council is representative of the various managerial bodies, teachers' unions and associations, the Universities, and the Minister. Generally speaking the Council requires for the purposes of registration a university degree or equivalent and in addition a post-graduate diploma in education recognized by the Council. Since 1942 the Council has insisted on a satisfactory knowledge of Irish [72]. Registered teacher status entitles one to teach *any* subject in the curriculum, however, there are moves to restrict teaching to one's degree subjects. Recommendations to this effect were made by the Higher Education Authority in 1970 and were generally well received [2]. Recent changes in the structure of higher education and the opening of new institutions such as Thomond College of Education have forced the Council to reassess its requirements. In any event it is unlikely that the Council will survive the present restructuring in higher education and it now appears likely that its functions together with enlarged responsibilities in teacher education generally will fall to a special Authority on the model recommended by the Planning Committee [49] on the establishment of a Teacher Training Authority.

As long as the private character of secondary education persists the Register of Secondary Teachers must remain somewhat less than fully effective as a regulatory device. This is true simply because the Register only applies to those who seek registration as secondary teachers. It was not always necessary to be a registered teacher in order to hold a teaching post in a secondary school. Since the appointment of staff in secondary schools always rested solely with the school managers subject only to the Department's requirement that schools in receipt of State-aid employ a minimum number of registered teachers, that requirement fulfilled,the employment of additional staff was not regulated by the Department. Neither were the qualifications of such teachers subject to Department control. While it is true nowadays that virtually every school is in receipt of State-aid and therefore subject to the Department's quota system for school staff nevertheless it is still possible even today for school authorities to hire teachers ex quota as long as their salaries are not a charge on the State. In such instances only the school manager has to be satisfied as to the teacher's qualifications, however, it is uncommon nowadays for unqualified people to find posts as secondary teachers.

Since the training of secondary teachers in Ireland is predominantly the responsibility of the Universities it is prudent to examine the history and nature of their involvement. As early as 1898 Trinity College, Dublin showed some interest in providing courses for future secondary teachers. The initial move towards formal training of secondary teachers was made at Trinity College in that year when a few graduates sat for an examination in History and Theory of Education and Practice of Teaching [72]. University interest in secondary teacher training was not sustained at Trinity College and nothing permanent came of the initial venture. However, the Royal University instituted a Diploma in Teaching for its own graduates in 1898 and from 1905 collaborated with Alexandra College for women in Dublin in providing teacher training for women. This venture and another independent effort run by the Ursuline Sisters at St Augustine's Training College for women in Waterford were subsequently discontinued. The training College for women at Waterford is interesting in that it was recognized not by Irish universities but by the Cambridge Syndicate and in a sense paralleled English University Education Departments [83]. University interest in secondary teacher training at that time led to the establishment of Departments of Education in Irish Universities. The first Professor of Education in Ireland, Edward P Culverell, was appointed in 1905 at Trinity College. The University subsequently acted as an examining body for a Teachers' Certificate and Diploma for women only, the candidates coming from Alexandra College [72]. The connection was later discontinued. University College, Cork, then a Queens College, opened a Department of Education for Secondary Teachers in 1904-5 and over the next decade the newly established National University of Ireland made appointments in Education. University College, Dublin acquired a Professor of the Theory and Practice of Education in 1911. University College, Cork appointed a Professor of Methods of Education and in 1914-15 University College, Galway entered the lists with its own Professor in Education. Queens University, Belfast also appointed a Professor in Education in 1914-15. The aim of the University Education Departments was to cater for the professional study needs of secondary and technical school teachers as well as national teachers and to provide a course of study for Arts and Science graduates intent on becoming Secondary teachers. These multiple objectives were achieved by awarding two diplomas, the Ordinary Diploma of Education and the Higher Diploma of Education. The Ordinary Diploma was a course of professional studies lasting one year for those who had completed the Training College course i.e. national teachers. The Higher Diploma was reserved for graduates [72]. The Ordinary Diploma was discontinued in 1947/48 but the Higher Diploma is still awarded by all the University

Departments of Education. The decision to confine their activities to a consecutive course of teacher training for secondary teachers i.e. degree plus post-graduate diploma was no doubt influenced by prevailing attitudes. Basically, few disagreed with a graduate's claim to be sufficiently competent to teach, however, a further year of professional study, the one thing the degree programme lacked, clinched the issue. The particular and continuing arrangements for a *consecutive* teacher training were no doubt given prominence of place due to the decision of the Registration Council in 1916 to adopt the prevailing English view when it framed its regulations. What is surprising is the fact that these regulations proved so durable even under a new administration. The regulations are so framed even today in the 1970s. The education and training of Secondary teachers in Ireland today is primarily a University preserve and the pattern is still consecutive specifically, Secondary teachers must be graduates and in addition possess the Higher Diploma in Education. The Registration Council insists on a certain oral competence in Irish in addition to formal qualifications adn the teacher is duly registered after one year's service as a secondary teacher.

The University Departments of Education in Ireland have laboured under the same disabilities as University Departments of Education everywhere. As yet Education as a subject has hardly been accorded full recognition as a University subject in Ireland. This is not surprising since the reputation of a Department was based primarily on its programme for the Higher Diploma in Education for many years. From its inception the Higher tiploma has been a one-year course of professional study including practice teaching. In recent years it has been severely criticised for its part-time nature, theoretical bias, teaching practice arrangements and entry standards [2]. The course requires one year of part-time study so organized that students spend approximately ten hours a week on a classwork and four hours per week on teaching practice in a secondary school [84]. The programme as such has developed and continued to be influenced not by the actual requirements of teachers in Irish secondary schools but by the requirements of the Registration Council which have changed little in half a century. In addition to the Higher Diploma the University Departments of Education offer a full-time two year programme for graduates leading to an M.Ed degree of the University. The role of the Departments of Education has been expanded in recent years since the Universities have become involved with the education and training of primary teachers. New arrangements in higher education in Ireland provide for University involvement in primary and secondary teacher training by way of the B.Ed degree programmes in the Recognized Colleges and their own primary degrees and Higher Diploma of Education and post-graduate M.Ed programmes.

8. The Education and Training of Vocational Teachers

The Minister for Education prescribes the qualifications for Vocational teachers. The relevant document is Memorandum V.7 of the Department which is currently under review. A university degree or professional qualification is required for most subjects.

It is not necessary for this category of teacher to possess the Higher Diploma in Education or equivalent pedagogical qualification. Once again the attainment of degree status is considered sufficient evidence of ability to teach. However, graduates who enter the vocational sector as teachers are more likely to spend a good deal more of their time teaching their degree subjects than if they entered secondary teaching. As a rule Vocational teachers are allowed to confine their teaching to subjects in which they are qualified. The promised implementation of such a *regulation* across the whole spectrum of second level education is still awaited.

Extra-university training is provided for Domestic Science, Art and Physical Education teachers and for teachers of Metalwork and Woodwork and Rural Science. Specialist teachers such as Domestic Science, Art and Physical Education and Music teachers may be registered by the Registration Council on the basis of their specialist diplomas and thereby qualify to teach in secondary schools. Such teachers are confined largely to teaching their subjects [78]. They also qualify to teach in Vocational schools. On the other hand, the vast majority of Woodwork, Metalwork and Rural Science teachers are employed in the Vocational sector. Their training is provided directly by the Department of Education at various sites throughout the country but plans are well advanced to centralize all such training activities at Thomond College of Education in Limerick, the only College of Education for second level teachers in the State.

The Department of Education's direct involvement in the training of Vocational teachers arose out of necessity. Emergency measures were introduced after the 1930 Vocational Education Act to supply the system of Vocational Education with a sufficient number of teachers in technical subjects. Prior to the Act teachers of applied science and technology in the employ of the Department of Agriculture and Technical Instruction were trained at the Universities and the Royal College of Science, an arrangement which continued after that Department was subsumed in the Department of Education of the Irish Free State later the Republic of Ireland. While this arrangement supplied the system of technical education with graduates there were no corresponding on-going arrangements for the training of manual instructors, Woodwork and Metalwork teachers or Rural Science teachers, categories of teachers in short supply in the system. The Department of Education assumed direct responsibility for the training of teachers in these categories and since the 1930s the Department has organized training courses on an ad hoc basis at irregular intervals in rented accommodation in Vocational schools. Such courses were staffed by one or two appropriately qualified staff members usually seconded from the Vocational system for that purpose and assisted by part-time help. The duration of such courses was variable depending upon the category of teacher and entry requirements but over the years the courses of training settled into their own pattern and in recent years programmes of definite duration have been established at various centres throughout the country.

The Department of Education has always tried to maintain an adequate supply of teachers of practical subjects in the Vocational schools by recruiting candidates directly from the trades. Trade experience including in some instances completion of apprenticeship requirements has been the principal entry requirement for such training courses. The cost of training including fees and maintenance allowances are paid by the Department. Manual instructors, primarily teachers of practical subjects have been recruited and trained in this way by the Department. Manual Instructors in Woodwork and Metalwork undergo a two year course. The Metalwork course is conducted at Ringsend Vocational School, Dublin while the two year Woodwork course has been located at Colaiste Charman, Gorey since 1954. The latter college also runs a one-year course in Woodwork and Building Construction for fully qualified tradesmen with supervisory experience in the building industry. A new three-year course for Woodwork teachers providing specialized training, general education and pedagogical training for candidates with Leaving Certificate as an entry requirement began in 1966. Similar arrangements existed for Rural Science Teachers who have since 1965 been required to complete a three year course of training at Crawford Municipal Technical Institute, Cork. The Department organized its first training course for such teachers in 1935 during a period of acute shortage of Rural Science teachers. A special two year training programme was inaugurated and trainee teachers spent the first year in the Crawford Technical School in Cork and the second at the Agricultural College in Glasnevin, Dublin [85].

Since the inception of the Department's training programme in Rural Science in the 1930s approximately thirteen courses have been run. Graduates in Agricultural Science were recruited during this period also and appointed as Rural Science teachers after a two week course in teaching methods. As already stated such courses are conducted under the auspices of the Department of Education. They are intensive courses and include specialized and pedagogical training and generally special arrangements are made by the Department so that candidates in training may fulfil the Irish language qualification demanded of all second level teachers in the State. Successful candidates are awarded the appropriate Teacher's Certificate of the Department which in addition to being the normal qualification for such posts in Vocational, Comprehensive and Community Schools is usually recognized for the purposes of registration by the secondary teachers Registration Council [86].

The normal way to qualify as an Art teacher is to secure the Art Teacher's Certificate of the Department of Education which is obtained by collecting successes in the Art Group of the Technical School Examinations at intermediate and advanced level. Prospective teachers must pass the Department's examination in the principles of teaching Art. While in theory candidates may qualify by independent study in practice most prospective teachers attend the National College of Art and Design in Dublin, the only recognized College of Art in the country, or one of the Vocational Education Committees' Schools of Art. The National College of Art presently administered under the National College of Art and Design Act, 1971 and until the Act administered directly by the Department of Education is not primarily concerned with teacher training. Relatively few diploma holders enter the teaching profession. However, the College's diploma is recognized by the Department for the purposes of teaching and in general the Department's requirements for recognition as an Art teacher in Vocational Schools are accepted for registration as a secondary teacher [78].

Domestic Science is by definition in the Vocational Education Act, 1930 a technical subject as are Music and Art as well as the other normally accepted technical subjects. Their mention in the Act brings them under the purview of the Minister for Education on whom responsibilities devolve for making adequate provision for an adequate supply of qualified teachers. However, the training of Music teachers is adequately catered for by the Universities and the usual qualification for registration is a degree plus a teaching diploma or the Diploma in Music Teaching of University College, Dublin. The position in relation to Domestic Science Teachers is somewhat more complex. From 1902 Domestic Science teachers have been trained in Ireland. Over the years the arrangements for training were reorganized from time to time and the course was conducted at different locations switching from the Kildare Street School of Cookery in 1902 to the Irish Training College for Domestic Economy in Kilmacud, Co Dublin and later in 1941 to Cathal Brugha Street, Dublin. The course found a permanent home at a new College, St Angela's College of Domestic Science, Sligo, opened for that purpose in 1952. The course was extended from two to three years, the entry requirements were stiffened and provision was made for practice teaching [85]. The same order of Nuns, Dominicans, opened a second college, St Catherine's, Sion Hill, Co Dublin to extend their training capacity. These Colleges are private institutions in receipt of State aid and have been for many years responsible for the training of the State's Domestic Science teachers. The course of training and general institutional arrangements have evolved over the years subject to Ministerial approval in certain matters of course of study, appointment of staff and admission of students. The sessional and final diploma examinations were until recently, conducted by the Department [78]. The Colleges' diplomas obtained after three years successful study are recognized by the Registration Council and by the Department for teaching in Vocational Schools where the majority of diploma holders have found employment. New institutional arrangements have affected this area of teacher training as is the case in other areas and while the form of the new arrangements has been outlined the detailed working out in practice is in progress.

The Department's teacher training activities have also extended to Physical Education. For many years there were no facilities for the training of male teachers in this subject in Ireland and small numbers were trained in the U.K. The need for such teachers was met primarily by ex-army personnel appropriately trained in service. Female teachers were until the early seventies trained at two colleges, St Raphael's College of Physical Education, Sion Hill and Ling College. The course was of three years duration and candidates were required to hold the Leaving Certificate as an entry qualification. After successful completion of the course students were awarded a college diploma in Physical Education which was recognized for teaching in Secondary and Vocational Schools [78]. These colleges were closed following a reorganization of training provision and their functions were concentrated in a single new institution, the National College for Physical Education a co-educational institute offering a four-year degree programme in Physical Education and another subject which opened in 1973 at Limerick. Subsequently the National College of Physical Education was subsumed in Thomond College of Education a new College for the education and training of teachers of Physical Education, Woodwork, Metalwork, Building Construction, Rural Science and Engineering Subjects at second level. The Department has thus rationalized its teacher training operations by concentrating the bulk of its provision at Thomond College a new style institute of higher education. Such a move is obviously linked to the Department's policy aim of an all-graduate teaching profession but the actual working out of programmes has yet to be concluded. However, while the path may be difficult it is unlikely that insurmountable obstacles to degree status for these programmes will arise in view of the fact that these programmes are likely to be validated by the National Council for Educational Awards a new awards body with different ideas on degree status.

9. The Present Situation

The teacher education provision in Ireland is currently in an active state of reorganization directed ultimately to a transformation more fundamental than any changes since the founding of the State. The root cause of the present interest in teacher education and training is not essentially a concern for teacher education per se although such interest would not be unwarranted, but is rather a combination of factors including justifiably, a desire to improve things in the teaching training sector. The impetus to restructure higher education, the development of new institutions and structures and the Minister's aim to achieve an all-graduate teaching profession have all been contributory causes of change in this sphere.

Changes have been most visible and pronounced at an institutional level where the number of Training Colleges has been reduced to three recognized colleges still under private control but reconstituted as Colleges of Education associated with University Departments of Education. The immediate consequence of such links is the attainment of degree status, a classified B.Ed., after successful completion of a restructured *concurrent* programme of academic studies and professional studies including teaching practice, extending over three years. In future all new primary teachers will be graduates having completed their education and training at one of the three recognized training institutions viz. St Patrick's College of Education, Our Lady of Mercy College of Education or Church of Ireland College of Education. Thus the new route to primary teaching is via theColleges of Education in all instances, after three years training for those who qualify on the entrance examination and one year for university graduates.

It is interesting to conjecture on whom the burden of the new arrangements will fall. The teachers certainly appear to be gaining at least from the point of view of the profession. However, implicit in the new link is a certain diminution of the power of two parties, the Training Colleges and the Department to the apparent gain of the Universities. Has the new scheme ushered in a new era in teacher training in Ireland, an era which will be remarkable for the Department's will to devolve control of teacher-training on a new partnership?

At second level, teacher training provision is still diversified but less so than in previous decades. The trend towards an all-graduate teaching profession is evident and movement in that direction is actively promoted by the Department of Education. At present the majority of post-primary teachers are graduates and many of those serving in Secondary schools and a good percentage of those graduates in Vocational schools possess the Higher Diploma in Education of one of the universities. The Universities, therefore, continue to be the training grounds for a majority of post-primary teachers providing primary degrees followed by a diploma in the theory and practice of education i.e. a *consecutive* teacher training pattern. At present teachers of academic subjects in all post-primary schools must be graduates which status is still sufficient qualification for service in Vocational schools. However, teachers in Secondary, Comprehensive and Community schools must in addition satisfy the requirements of the Registration Council which include the Higher Diploma in Education if they wish to teach academic subjects in those schools.

A teacher registered on the basis of a degree plus a diploma in education is placed on the open registrar and is therefore permitted to teach *any* subject on the school curriculum. However, the Department is working towards a situation where all teachers of academic subjects in post-primary schools will teach only the subjects of their degree.

The supply, recruitment and training of teachers of technical subjects in the Vocational schools, and increasingly in Comprehensive, Community and Secondary schools, is the responsibility of the Department of Education. In recent years the Department has begun to rationalize provisions for training such teachers and eventually it is envisaged that the bulk of the provision will be concentrated at Thomond College of Education, Limerick, a new concept in teacher training in Ireland. Initially the college has catered for Physical Education teachers but ultimately it is envisaged that Metalwork, Woodwork, Building Construction, Rural Science and Engineering subjects teachers will be trained there. Such training programmes are likely to begin in 1979 on a phased basis as existing courses close down and transfer to the Limerick campus. The programme at Thomond College is - and only the Physical Education programme is currently available - a concurrent and integrated programme of academic and professional studies including teaching practice extending over four years culminating in the award of a classified NCEA degree. In addition trainee teachers are expected to attain teaching competence in *two* subjects which they study in each of the four years. The programme has been accorded recognition for the purposes of Registration by the Registration Council and graduates are admitted to the *open* register but generally confine their teaching to their two subjects. The present position therefore is that courses in technical subjects already begun at various locations will be completed with the award of the appropriate Teacher's Certificate of the Department. New courses will be organized and centralized at Thomond College and will lead in all probability to degrees awarded by the NCEA whose validating procedures are so informed as to accommodate non-traditional degree structures. Once again the progression towards an all-graduate teaching profession is evident and the first graduates with Physical Education as a degree subject graduated in 1975 from the Limerick complex.

While much of the facilities for training technical teachers will be concentrated at Thomond College of Education some modifications in traditional avenues to qualification have sufficed. The training of Home Economics[1] teachers falls in the latter category and is presently provided for in the same institutions restructured to suit modern conceptions. Thus St Angela's College of Education for Home Economics has become a Recognized College of the National University and predictably such arrangements will fix the pattern of training in that subject. *The trend towards an all-graduate profession is ever visible in the reorganization of teacher training.*

1. The new title is consonant with a new science-based approach to training in this area, and the 'Domestic Science' label is no longer appropriate. The new university associations - St Angela's with University College, Galway and St Catherine's with Trinity College, Dublin - are designed to gain degree status for a science-based programme with more emphasis on the underlying academic disciplines.

It is pertinent to point out at this point that Ireland now has two kinds of Colleges of Education, one concerned exclusively with primary education and the other charged with specific responsibilities in relation to second level education only. As yet there is no formal apparatus for collaboration and the divisions traditionally separating primary and post-primary teachers seem destined to be perpetuated by some institutional arrangements. In this context the Department seems to be at odds with itself supporting, indeed promoting the whole arrangement, while on the other hand accepting the concept and ostensibly promoting the concept of a unified teaching profession. Proposals have been tabled by a special Planning Committee on the formation of a Teacher Training Authority. The Authority as recommended would be representative of the teaching profession as a whole exercising responsibility in relation to the *whole* profession as follows [49] (p.8):

> Excluding matters of salary, emoluments and conditions of service, to consider how best to educate teachers, how best to foster, encourage and promote the educational and professional interests of teachers; to advise the Minister for Education and the other relevant authorities on all these matters; and to act as a registration council for teachers.

It is therefore envisaged in the report of the Planning Committee that the Authority would discharge a dual role functioning as the advisory body on teacher education and acting as a registration council for teachers "with ultimate authority in that respect". The report submitted in 1974 is still under consideration but in the interim widespread support for the idea of such an Authority has been sustained and it seems likely that the recommendations will be implemented in some form.

10. In-Service Education of Teachers

Meanwhile, there are signs that Irish teachers as professionals are becoming more attuned to developments in education and more aware of the demand for continuing self-education this entails. The minimum educational requirements and the subsequent in-service education of its members must be among the legitimate concerns of the profession as a whole. This view is supported by the Planning Committee in its report and one of the specific functions of the Authority as envisaged is [49] (p.9):

> To organise, arrange and advise on in-service courses for teachers; to organise, arrange and advise on courses for serving teachers leading to the acquisition of specialist skills or additional qualifications which would be recognised by the Department of Education; and to approve and arrange for such other courses as it deems necessary.

The road to professional status, a plateau not yet achieved by Irish teachers has been difficult and the withholding of that recognition by managers and Department alike down through the decades has given priority of position to matters other than demands for proper facilities for the continuing education of the teaching force. The absence of true recognition of teachers as professionals - by themselves, because they did not aspire to it and by the authorities, because they did not wish to concede it for political and economic reasons - has retarded the growth of provisions for in-service education. The Department of Education, admittedly in straightened financial circumstances over the years was never under real pressure to commit resources to in-service education. The lack of appreciation for teaching as a profession contributed to a denial of priority status for teachers' continuing development. Thus the continuing education of teachers in service was largely a matter of private initiative over the years, initiative often channelled into the formation of subject associations and the like. The last twenty years has seen increased activity by such associations such as the Mathematics Teachers Association, the Science Teachers' Association and others like the History Teachers Association. These associations have been active running courses, providing facilities and writing reports and in other instances acting as information centres on their subject area and its teaching. In recent years one such association, the Computer Education Society of Ireland has been busy promoting computer education in Irish schools and training teachers by way of annual inservice courses in conjunction with year-round services and advice for interested teachers. Such associations are helped in many ways by the Department including finance, but they are essentially associations of subject enthusiasts and not part of any official plan.

In-service education is not a new discovery in Ireland, the Department of Agriculture and Technical Instruction ran such courses during summers early in the century, however, the concept of in-service education as a necessary service for professional teachers to enable them to broaden and deepen their knowledge, acquire new skills or study new areas was scarcely understood. Since the founding of the State major in-service provision has coincided with emergency measures to cope with new situations. For many years after the founding of the State the Department provided extensive in-service provision to enable teachers to become competent to teach Irish and through the medium of Irish [74]. These measures were instituted in pursuit of the *political* objective of reviving the Irish language through the schools and were not inspired by strictly educational ideals. Again in the early sixties the introduction of the new curriculum in mathematics led to increased activity in in-service education by the Department of Education. In the intervening years the Department made little more than token concessions to in-service education of the teaching force. Increased activity in this sphere was occasioned by the introduction of the new child-centred curriculum in the early seventies but like all action of an emergency nature its intensity cannot be sustained. The Department's contribution to in-service education therefore has been small increased only at times of great need such as are occasioned by curriculum changes.

In recent years, however, the Department has displayed a willingness to fund research. A new Educational Research Centre, the first and only one of its kind in Ireland, was opened at St Patrick's College of Education in 1965 and has a permanent director. An allocation to educational research has appeared as an item on the Department estimates for the past number of years and seems likely to gain permanent status. Besides this the Department has funded curriculum projects and several projects have been mounted in recent years. Such activity is quite new in Irish education and considerable interest has been generated by science teaching projects in Dublin at the School of Education, Trinity College, and at Shannon Comprehensive

School near Limerick. In addition to ISCIP, Trinity College has been the headquarters of the Public Examinations Evaluation Project (PEEP) which has been responsible for a number of changes in the format of the Intermediate and Leaving Certificate examinations. The need for training and retraining of teachers has been made increasingly evident by such activity and in more recent times the situation in in-service education has improved. One hears of more people on leave of absence, more teachers seem to be attending important conferences and the universities have instituted diploma and degree courses aimed at serving teachers. Since the early seventies Teachers' Centres on similar lines to those in the U.K. have been in operation at various centres throughout the country. These Centres are funded by the Department of Education and provide a range of facilities and courses for serving teachers throughout the year. A major weakness in the Department's provision apart from its meagre size has been the fact that in-service courses almost invariably were confined to the summer months leaving no provision for such courses during the school year. In this regard the Teachers' Centres are indeed welcome providing as they do year round facilities. Another important development in the area of in-service education for Irish teachers occurred in March, 1976 when the Minister for Education in his address to the first meeting of the Governing Body of Thomond College of Education made it clear that the College would have an important role to play in the in-service education of teachers. In his words [87] (p.3):

> There is another aspect of education to which Thomond College will be in a position to make a substantial contribution. This aspect is most clearly expressed, I think, in the term "recurrent education" and it

> will undoubtedly assume greater prominence in the future when economic circumstances permit the allocation to it of an increasing amount of our national resources. In the meantime, of course, we cannot neglect such development as is within our means for in-service programmes in that updating and renewal of pedagogic and professional skills which guarantees the continuing health of any profession.

There has been, therefore, a College of Education in Ireland since 1976 with a special responsibility for in-service education. This represents a major advance on the previous decades and no doubt in-service education will become a more important activity in education than heretofore. However, grand plans must be tempered by economic reality and in all of this it is important to be mindful of the Minister's reference to "when economic circumstances permit the allocation to it of an increasing amount of national resources". The Department does not have a good record of allocating resources to in-service education presumably because there were greater priorities. Perhaps the emerging teaching profession can convince the Department to accept in-service education as an important priority.

11. Mathematics Teaching in Ireland - A Brief Historical Note

It is difficult to be precise about when mathematics entered the school curriculum in Ireland. However, there is clear evidence that mathematics as such received attention in the hedge schools[1] which flourished in

---

1. See Chapter II p.17 for discussion.

Ireland from late seventeenth to early nineteenth century. These schools offered instruction at elementary and post-elementary levels and in fact, for a long period during the Penal Times they provided the only educational preparation for Irish clerical, and other students, who completed their education in Irish colleges abroad. The instruction generally was very variable and there is no reason to expect that it was particularly good in relation to mathematics. However there is evidence that individual teachers were good and it seems to be the case that mathematics was taught and to a reasonably high level for the day in some schools but this can hardly be typical of a system with poorly qualified and ill-educated teachers. It seems likely, due to the elementary nature of many of the hedge schools, that instruction in mathematics was confined to the simple laws of arithmetic and computation. However, one John Conwill who conducted a hedge school at Ballinabranagh, Co Carlow in the early nineteenth century provided instruction in the rudiments of algebra, elements of plane and solid geometry, trigonometry and conic sections [11].

Universal elementary education became available in Ireland when the national system of education was introduced in 1831. Instruction in these national schools was confined to the '3-Rs', some grammar and geography together with needlework in girls' schools. Thus arithmetic can be fixed in the general primary school curriculum from an early date. However the instruction was mechanical and based on the Commissioners lesson books which were taught by the monitorial system. Mathematics and science were optional and rarely taught outside the Model and Convent schools. Following the Powis Commission's (1870) report on Primary Education in Ireland the 'payment by results' system was introduced into Ireland in 1872. A programme of instruction for each class was drawn up for examination purposes and the obligatory programme included the '3-Rs', geography, needlework for girls and agriculture for boys in rural schools. Algebra and geometry were taught as extra subjects outside normal school hours. In this way arithmetic was perpetuated virtually as the only 'mathematics' taught in Irish national schools. Despite new programmes and various reforms the position in relation to mathematics teaching in Irish primary schools remained virtually the same for the next hundred years.

The 'payment by results' system was replaced after a revised programme for schools was promulgated in 1900. The programme retained arithmetic as an obligatory subject but in addition mathematics was recognized as an optional and extra subject. A set of programmes for schools of different sizes was issued in 1904 and remained in force until 1922. In that year a new programme was provisionally adopted by the new independent administration and it too made arithmetic a compulsory subject. A Second National Programme Conference supported the provisional programme with some amendments and the curriculum introduced in 1926 as a result of this conference has remained in force down to 1971. Accordingly, Irish, English, arithmetic, history and geography, music and needlework (girls) became obligatory in all schools. Algebra and geometry were also obligatory under certain conditions in schools with more than one teacher. *However, in 1934 algebra and geometry became optional in one and two-teacher schools, and in three-teacher mixed schools as well as in all classes taught by women* [2]. This effectively confined the teaching of algebra and geometry to large urban boys schools. The primacy of arithmetic over algebra and geometry was further emphasized by the introduction in 1929 of the Primary Certificate Examination which became compulsory in 1942 for all pupils completing sixth standard. This written examination required pupils to sit papers in Irish, arithmetic and one other subject, and remained in force until abolished in 1967. These official regulations allied with the large number of small schools in Ireland (in 1952 when the Council of Education reported on primary education only 403 schools from a total of 4 876 had over four teachers) effectively confined mathematics instruction to arithmetic for the majority of Irish primary pupils. Needlework, for example, was considered more important for girls than algebra or geometry and consequently virtually no algebra or geometry was taught to girls.

The arithmetic syllabus proceeded from number and simple processes such as addition via tables to multiplication and to operations with decimals and fractions, percentages, ratio, simple interest and discount, averages and mensuration in the fifth and sixth standards. Emphasis was placed on arithmetic as a mental process and the teaching was characterized by drill. The aim of the programme was to enable pupils to meet their ordinary needs in society. Since pupils must buy and sell, measure and weigh they must therefore be able to add, subtract, multiply and divide, measure lengths and calculate volumes and deal with money matters such as income and outgoings and profit and loss. Algebra and geometry were introduced in the fifth standard and algebra was treated as generalized arithmetic concentrating on the use of algebraic symbols and manipulations while geometry was developed from mensuration. However no great importance was attached to the study of algebra and geometry in the primary schools since arithmetic was considered a sufficient basis for the pupils' needs in relation to society and/or further education in post-primary schools.

Mathematics teaching in the secondary or intermediate schools was encouraged by the advent of extern examinations in Ireland in 1879. Following the passing of the Intermediate Education Act, 1878 public monies were made available to intermediate schools for the first time in the form of results fees based on pupils' performance on the Intermediate Education Commissioners' examinations. Examination subjects were grouped into seven divisions and examinations were held in three grades, Junior, Middle and Senior Grades. Mathematics, including arithmetic and book-keeping was specified as one of the seven original divisions in the Schedule of Rules appended to the Act. Candidates had to present for examination in two or more divisions and boys were obliged to select from Greek, Latin, English or Mathematics. Girls were expected to select one of their two examination subjects from English, a Modern Language or Mathematics. However, girls could pass in Mathematics by passing in arithmetic alone. By 1894 candidates had to pass in four subjects which had to include for boys, English, a second language and a mathematical subject. These regulations remained in force until 1902. In that year two separate courses viz. the Grammar School Course and the Modern Course were introduced in the Junior, Middle and Senior Grades and all subjects were allocated equal marks. Following the abolition of the Intermediate Education Board in 1923 a new programme for secondary schools was adopted in 1924 which remained in force until replaced by the new mathematics curriculum in 1964. The Junior, Middle and Senior grades were replaced by the Intermediate and Leaving Certificate Examinations and pupils were required to follow a curriculum which had to include Irish or English, Mathematics, a second language, History and Geography, or Science, or Latin or Greek. Boys were obliged to present for Mathematics at the Intermediate Certificate and Leaving Certificate

Examinations and the award of a certificate was dependent upon a pass in Mathematics. Separate honours and pass papers were available for the Leaving Certificate, however, only the higher course was available for boys at the Intermediate Certificate. Girls were allowed to take an easier Elementary Mathematics course for examination at Intermediate Certificate level and their certificate examinations were not dependent upon passing in Mathematics. These extern examinations have remained the single most powerful influence on mathematics teaching.

There were no changes except for a shortening of courses in 1939/40 in the Mathematics curriculum in Irish secondary schools until the sixties and the subject was taught and examined as three separate subjects; Arithmetic, Algebra and Geometry with the emphasis on Algebra and Geometry. Some coordinate geometry, Calculus and Trigonometry was included in the honours course for the Leaving Certificate. The Leaving Certificate course was built on the Intermediate course. Mathematics teaching was rarely coordinated with science teaching in schools and consequently the approach to mathematics was extremely academic. Applied Mathematics was taken by a minority of students and because of the content of this syllabus it might better have been termed theoretical Mechanics. Grave concern over the lack of science teaching facilities in schools surfaced in the early sixties and a special trust was set up to help equip schools. During the same period incentive schemes to attract mathematics teachers into secondary education were tried. Neither the incentives nor the private trust were successful and both were discontinued. However, the Department pressed ahead with the introduction of the new mathematics curriculum in 1964. The plan was to phase in new material over a period of years. Euclidean geometry was phased out in favour of a Papy-style approach (Belgium school) and in general the rest of the syllabus was similar to those introduced elsewhere with the emphasis on sets and structure. As a general comment it can be said that more of what used to be university mathematics has percolated down into Irish schools, for example, the ordinary level paper in mathematics at Leaving Certificate includes some group theory calculus and statistics and in more recent times linear algebra and probability have found their way into the curriculum for Leaving Certificate.

12. The Present Position

A new child-centred integrated curriculum[1] was introduced into primary schools in the school year 1971/72. This represented a complete break with the traditional subject-centred approach. The aims of the new curriculum in relation to mathematics were expressed as: (1) kindling a lively interest in mathematics; (2) giving the child a grasp of basic mathematical structure and content; (3) laying a foundation for further work at post-primary level; (4) leading the child to a realistic level of skill in computation [65]. The whole approach to the curriculum is informed by the developmental psychology of Piaget. Guided experimentation and discovery methods are used and children are brought via free play and experimentation and use of structural materials to an understanding of the mathematical concepts involved. The child is expected to learn by doing and consequently teachers are expected to provide the child with opportunities to explore mathematics by use of materials from his own environment and other appropriate materials so that the child learns through his own activity. Mathematics is integrated with other

1. The Irish Department of Education produced a teachers' guide, ran courses for teachers and ultimately introduced teachers' centres. This pattern is reminiscent of the strategy used by the Nuffield Project team in 1964.

school activities such as Art and Crafts and nature studies. Record keeping is encouraged and attention is directed towards developing the mathematical vocabulary of the child. The progress of individual children and groups is charted and used as valuable feedback. It is obvious from these remarks that the general philosophy, pedagogical approach and syllabus content has been influenced by modern mathematics programmes for this age group such as Nuffield Mathematics for Primary Schools i.e. the Nuffield Mathematics Teaching Project (5-13).

The syllabus for Infants and Junior classes deals with such activities as sorting and classifying, relations, ordering, counting to 10, and recognition and writing of number symbols. There are activities to help the child form the concepts of size, shape, quantity, weight etc. Attention is devoted to addition, including associative and communitative properties, and the exploration of space through experience with 3-dimensional shapes. Multiplication and division are deferred until Standards III - IV and it is during this time that fractions are introduced. Children also gain experience of translating simple problems into number sentences in these classes. The work in Standards V - VI is devoted to number concepts such as odd and even numbers, square, prime and composite numbers. Factorization is introduced in these standards and more work on fractions. The work with numbers leads to decimals percentages, and averages. The use of the place-holder in these grades leads to the use of x as a variable followed by simple equations. Further work on shapes is included and the notion of perpendicular and parallel lines is developed. Simple relationships between sides, angles and diagonals of geometric shapes are explored and further exercises on symmetry are included. Area of rectangles, parallelograms etc. are computed using squared paper and geoboards. Some formulas for area are developed and used. In this way children are prepared in mathematics for transfer at 12+ to post-primary schools.

Two features have dominated the secondary school curriculum in mathematics in Ireland viz. the extern examinations and the university influence. Both have merged since the forties when the Leaving Certificate Examinations were coordinated with the university matriculation examinations for university entrance. The universities now approve the Leaving Certificate Examinations in matriculation subjects when they are in the draft stages. Thus the whole programme in mathematics is university-oriented. The examinations bias and university influence have circumscribed the teaching of mathematics in the schools. The approach portrayed in the most popular text-book is an abstract, purist approach and contrasts completely with secondary programmes in other countries in applicable mathematics. There is a single standard syllabus and therefore in practice no alternatives are available. Because of the length of the syllabus and the examinations little time can be devoted to motivating and developing topics or serious applications. Copies of current syllabuses for Intermediate and Leaving Certificate courses are included in Appendix A.

13. The Training of Mathematics Teachers in Ireland

Traditionally all primary teachers in Ireland teach mathematics in primary schools. This has been a major influencing factor on the syllabus at that level since these teachers received no special or extra training in Training Colleges to prepare them for such work.

Consequently teaching was confined to arithmetic until the introduction of the new primary school curriculum. Mathematics has always been an *optional* examination subject in the Training Colleges and even today in the Colleges of Education remains so. The only exceptions are the Colleges of Education associated with Trinity College, Dublin, namely, the Church of Ireland and St Mary's College of Education. The courses in these colleges are organized around a central core of competencies including mathematics but the numbers trained are small compared to the other colleges. The present position then is that with few exceptions, primary teachers in training today in Ireland receive no special training in mathematics beyond what they receive in their 'methods' courses. Unfortunately, not many student-teachers in these colleges *chose* mathematics . Thus, in effect the preparation in mathematics of these teachers is secondary school mathematics. This has been the case since the Leaving Certificate course became the entry standard to the Training Colleges in the thirties. Nowadays candidates for training must have obtained a pass in Leaving Certificate mathematics.

For many years the only qualification required for mathematics teaching in Irish post-primary schools has been a primary degree. Provided a teacher satisfied the requirements of the Teachers' Registration Council he was placed on the open registrar which meant he could teach *any* subject on the curriculum. In recent years the Irish Department of Education has confined mathematics teaching insofar as possible to those teachers with *mathematics* in their degrees. Traditionally much of the mathematics teaching has been done by science graduates and graduates in commerce. However, much instruction in the schools in mathematics in past years has been conducted by teachers with no particular qualification in mathematics, many of whom *had no mathematics at all at university level.* Secondary teaching has not attracted mathematics graduates in anything like sufficient numbers over the years and even today suffers in this regard.

The preparation of mathematics teachers for Irish secondary schools has been confined to the universities where no special attention was paid to it except perhaps in the post-graduate diploma of education taken by most, but not all, secondary teachers. These teachers have not been supported by an adequate continuing programme of in-service education over the years and consequently mathematics teaching in Irish secondary schools is not what it ought to be. Matters have been helped somewhat by the formation of the Irish Mathematics Teachers Association in the early sixties and the advent of schools television programme.

The Vocational sector of the secondary system traditionally employed graduates and others to teach mathematics. Teachers of metalwork and woodwork, for example, are expected to teach some mathematics in the junior cycle i.e.. the first three years of secondary education. Those teachers of technical subjects who took the higher technological examinations of the Irish Department of Education in mathematics were also expected to teach mathematics in the vocational schools. The situation is virtually the same in this regard today despite the enhanced status of the vocational system and the common certificate examinations. The conditions of service in this sector are still specified by the Minister for Education and the requirements for mathematics teaching in this sector are otherwise the same as in all other secondary schools. Therefore, generally speaking, secondary mathematics teachers are graduates in mathematics, science, engineering and commerce augmented by teachers of technical subjects in some schools and persons with no particular mathematics qualifications in many others[1].

---

1. The Irish Department of Education regulates the actual mathematics teaching in the schools by altering the recognized syllabus from time to time. However, changes in the certificate examinations' format have been used more deliberately for this purpose in recent years. The work of the Public Examinations Evaluation Project centred at Trinity College, Dublin has motivated recent changes in the examination format of the mathematics papers in the Intermediate and Leaving Certificate Examinations.

CHAPTER VI

AN INNOVATIVE DEGREE PROGRAMME FOR TEACHERS OF SECONDARY SCHOOL MATHEMATICS IN IRELAND

1. Some Observations

An adequate mathematical education for a nation's children at all levels ultimately depends upon the quality of the mathematics teachers [88]. And the quality of the mathematics teaching force is directly related to the education and training of such teachers. That education and training must be adequate and appropriate whether it be University based and of the *consecutive* type or based on the *concurrent* model of Colleges of Education. It is imperative that attempts to reform school mathematics be accompanied by appropriate and sustained efforts to improve the education and training of school mathematics teachers. Such was not the case when the central authority in education in Ireland, the Department of Education,[1] introduced a new secondary school mathematics curriculum in 1964. After initial intensive activity in in-service training of mathematics teachers the effort was not sustained over a prolonged period nor supported by concomitant efforts to reform the initial education and training of new secondary school mathematics teachers. The initial training of Irish secondary school mathematics teachers has remained firmly in the hands of the Universities and is on the consecutive pattern which has meant in the Irish case the combination of a primary

1. Throughout this chapter and the thesis generally, Department of Education means the Irish government department charged with responsibility for education in Ireland, and is not to be confused with university departments of education.

degree which has remained largely untouched by developments in school mathematics with a higher diploma in education which has been severely criticised as inadequate [2]. The Department of Education has, therefore, in particular failed to address the problem of providing an adequate pedagogical training for its secondary school teachers generally but especially for its mathematics teachers. It is difficult to see how the Department expected to implement what was essentially a reformed *pedagogy* in secondary school mathematics without adequate educational support in this area for its mathematics teachers [89]. Belatedly in 1973 the Department of Education made it possible to pursue such activity in the education and training of mathematics teachers on a very small scale by founding the National College of Physical Education later subsumed in Thomond College of Education. However, a projected improvement in mathematics education at secondary level was hardly a primary consideration, nor did the Department envisage any important change in the pattern of initial training for secondary school mathematics teachers.

Despite its rather non-commital attitude towards mathematics in Thomond College of Education, the Department had nevertheless provided an *opportunity* for experimentation for anyone suitably placed, willing and qualified to exploit it by insisting on teaching competence in two subjects from the graduates of the National College of Physical Education i.e. Physical Education combined with one other subject chosen from a list of available subjects which included mathematics. Later so-called 'soft' options were phased out in favour of 'hard' options which were more marketable in employment circles and mathematics was retained. The rest of the chapter is devoted to chronicling an attempt to improve mathematics education in Irish secondary schools by addressing the crucial problem of teacher education in that sphere. It is a personal response to a perceived need in mathematics education by one person who was well-placed to exploit the opportunity provided perhaps unwittingly by the Department, an effort which resulted in a novel approach to the education of secondary school mathematics teachers in the Irish context and the formulation of an overall plan for an improved mathematics pedagogy in Irish secondary schools.

2. General Background - Motivation and Formative Influences

At the outset it is important to acknowledge the role of personal experience, prejudices and insights in educational research. Such considerations, far from being peripheral, play an important role in every educational enterprise and in many instances have had a profound effect on the nature of the reforms in school mathematics as witnessed by the direction taken by various pioneering curriculum projects in mathematics e.g. School Mathematics Project (SMP) and the School Mathematics Study Group (SMSG) in the U.S. Many of the first generation curriculum projects in school mathematics were initiated by persons or groups promoting their own particular responses to problems in mathematics education largely on the basis of personal taste and preference as opposed to systematic research. This is not surprising since a start must be made before anything can be accomplished. A start was made in the area of teacher education at Thomond College of Education in recent years by addressing the crucial problem of teacher education for mathematics teachers in Irish secondary schools, and what might be termed a first generation project in teacher education for Ireland was initiated there.

Inevitably the Mathematics Programme developed at Thomond College of Education for the education of aspiring secondary school mathematics teachers was shaped among other things by the personal experience, prejudices and insights of its author. In retrospect it is clear that even remote past experiences had considerable influence on the formulation of the programme. The desire to release pupils from the tedium of poor mathematics teaching was urgent and pressing since the author personally suffered under such a regime and was aware that the situation had improved little in the intervening years. The regime of mathematics teaching in Irish secondary schools perpetuated by an unimaginative Department of Education in league with a severely burdened teaching force was, and still is, less than conducive to good mathematics teaching. And that state of affairs could no longer be condoned by a concerned educationalist.

Some immediate prior experiences proved to have a considerable impact on the programme at all stages of development. A personal formal education and training in Mathematics and Physics accomplished outside Ireland and in the U.S. led the author to the conviction that his extra-Irish training placed him uniquely to exploit the situation at Thomond College and promote a new approach to the education of mathematics teachers for Irish secondary schools. Being extra-Department in attitude and training and possessor of a different set of experiences in mathematics after prolonged exposure to a different system of education actually enhanced the possibility of a new approach in Ireland. In this context it is important to emphasize that the author harboured no conscious loyalty to the existing system of education, mathematics education in particular, but was nevertheless vitally interested in mathematics education in Ireland.

The author nurtured more than the passing interest of a third level teacher of mathematics and physics in secondary school mathematics. This interest was reinforced and expanded by personal teaching experience in an Irish Regional Technical College at Sligo where his primary concern was the education and training of higher science technicians. Despite a minimum entry requirement of a pass Leaving Certificate which included mathematics the author was struck by the mathematical inadequacies of the students. A disquieting lack of skill was evident in computation with fractions and decimals and little or no facility with approximations, orders of magnitude and scientific notation was evident. Students had not progressed to a confident use of logarithm tables and most had no experience of slide rules. Many were unable to solve simple equations by transposition and beyond plotting points in the plane many were incapable of reading graphs. Their experience of school mathematics scarcely included calculus although most students knew the 'recipes' for obtaining some standard derivative and integral forms. These deficiencies were widespread as evidenced by a similar state of affairs in the Schools of Engineering and Business Studies in the author's own College, a situation which showed no marked improvement over three years intake of students - 1972 to 1974 inclusive. Indeed similar problems were experienced by colleagues in other colleges, problems which came to light at meetings, courses, informal gatherings and examiners meetings. This state of affairs, quite apart from implications for work in the Regional Colleges, served as a real indication of problems in the teaching of school mathematics in Ireland which helped to focus the author's attention on problems in school mathematics teaching. Similar difficulties with mathematics teaching in secondary schools have surfaced in recent years gaining widespread acknowledgement and attention in the U.K. as evidenced by the debate on a minimum core syllabus in mathematics for secondary schools [90]. It is fair to say that even yet in Ireland such problems have scarcely been *acknowledged* in official circles.

The problem in the Regional College context was to devise, teach and examine appropriate mathematics courses for higher technicians on two-year certificate and three-year diploma courses. On the premise that mathematics in such an institution served what can only be described as a 'service role' an applicable approach to mathematics was adopted. Two guiding principles were adhered to while the programme was being devised: (1) the mathematics personnel considered it essential to consult with colleagues in the serviced areas and to implement insofar as possible their considered suggestions; (2) only mathematics teachers sympathetic to the serviced areas and willing to learn about them should teach mathematics for those areas [91]. The author and his mathematics colleague in the School of Engineering collaborated in devising a common two-year programme in mathematics for Engineering and Science technicians. Many colleagues in the serviced areas were consulted and their advice sought. Some cited mathematical skills they used in their work and expected students to master, others supplied examples of situations in their subject areas. Much of this activity was informal, information being obtained during the course of staff meetings, coffee breaks and informal gatherings in the staff-room. *The mathematics personnel undertook to provide background and practice within a coherent mathematical framework which was intended to contribute to the students' education as well as their vocational training.* The common programme which evolved under these stimuli included basic work in computation, logarithms, coordinate geometry, graphs, functions, determination of experimental laws and derivatives leading to integration and the formulation and solution of simple first order differential equations in the first year. Elementary numerical analysis with Computing and Statistics formed the basis of the second year's work which was optional for students but recommended by the departments involved. Rigour in presentation was purposely diluted and a more intuitive, heuristic approach was adopted and the mathematics, insofar as the lecturers were able to do so, featured examples from the serviced areas. In practice, the author taught the Science technicians and his colleague the Engineering technicians. Later the common two-year programme was submitted as part of the Engineering and Science submissions and subsequently validated by the awards body, the National Council for Educational Awards.

It became evident during the course of teaching at Sligo Regional Technical College that the mathematics taught must be relevant to the needs of the student. Experience dictated that the needs of the student be determined with reference to the student, his job prospects and the expectations of employers of technicians. A consultative process was implied. However, the need to provide for the mathematical *education* of the student precluded the possibility of just presenting techniques without the adequate support of an appropriate mathematics background [92]. The power of mathematical tools lies in their potential for use in a variety of situations but such use demands an appropriate understanding of the mathematics involved. This concern for 'relevant' mathematics allied with the observed deficiencies of entering students in mathematics begged the question of what constituted a relevant mathematics education at secondary level. Obviously those students choosing the Regional Technical Colleges for their third level education had experienced a course in mathematics which was not relevant to their future educational needs. Upon examination this fact is not surprising since the secondary school mathematics programme in Ireland is greatly influenced by the demands of the university to the virtual exclusion of all other interests. There was something amiss with secondary school mathematics but if there was there were no simple solutions. However, the author obviously influenced by his experiences felt it worthwhile to seek a possible way of ameliorating the difficulty by investigating the meaning of a relevant education in mathematics at secondary level. Knowing that relevance as a concept is not absolute but in need of a referent, the problem is broadened but still pertinent. It is in pursuit of that referent for relevance in education that the author has come to teacher education and Thomond College of Education.

3. The NCPE/TCE Scenario

Thomond College of Education is a new development in teacher education in Ireland. It owes its existence to the Department's desire to centralize its training provision for special categories of teachers namely, teachers of Physical Education, Rural Science, Metalwork, Woodwork, Building Construction and Engineering subjects. However while centralization was an important consideration in the Department's plans one must also be aware of the Department's aspirations for an all-graduate teaching profession. Graduate status for these categories of secondary teachers could most likely be achieved in a College of Education context where special attention would be devoted to developing degree level programmes. What might now be described as the pilot phase of the Department's project was completed when students already nominally in their second year transferred to the newly constructed National College for Physical Education in Limerick. This college was administered for the Department by a small board of management.

From the outset the National College of Physical Education (NCPE) was committed to a four year concurrent and integrative degree programme in teacher education designed to prepare teachers in two areas of the secondary school curriculum. In many respects, the implications of this commitment were not fully understoood or anticipated and remained to be worked out. The approach was novel in at least four ways in the Irish context: firstly, it would culminate in the award of a degree, secondly, it was to be a concurrent programme i.e. professional studies were to be concurrent with personal studies with teaching practice taking place in each of the four years, thirdly, the integrative nature of the programme was promoted and emphasised as vital, fourthly the students were expected to study *two* areas in preparation for teaching in each area at second level although one of these areas had to be Physical Education. The degree programme evolved at NCPE was subsequently validated by the National Council for Educational Awards for the graduating class of 1975 and the first graduates were awarded a classified B.A. degree. Subsequent classes were awarded a classified B.Ed. of the National University of Ireland in 1977 pursuant on the Minister's directive that Thomond College of Education, incorporating the National College of Physical Education, seek recognized college status of the National University. Having attained recognized college status in 1977 the College was later directed to seek validation by the NCEA - the Government had changed in the interim. However, the fundamental aims of the College had not changed nor had its purpose. The newly appointed Governing Body of Thomond College of Education accepted its brief from the Minister for Education in March 1976, a brief which has remained unaltered. Some insight into the Department's aspirations for the new College can be gained by studying the Minister's address to the first Governing Body. Pertinent extracts are included here [87]:

> We do well to remind ourselves continuously that change and innovation in education depend on our teachers.
>
> ... I am inviting you to consider how to bring about change where change is desirable, how to conserve where conservation is vital, how to influence to a large extent the nature of education in this country...
>
> The Thomond College is constituted to cater for the *professional formation of specialist teachers of many categories*. It incorporates the provision already made for Physical Education and will, fairly soon, have provision on the site for other categories.
>
> There is another aspect of education to which Thomond College will be in a position to make a substantial contribution. This aspect is most clearly expressed, I think, in the term "recurrent education".
>
> Your College in accordance with the Government decisions of December, 1974 will be seeking recognized College status from the National University and with it *the award of degrees to those who have successfully pursued degree-level courses*. Here I must affirm once more that I am hoping to advance towards a position wherein teaching will be an *all-graduate profession*.
>
> [my italics]

No detailed advanced planning on curriculum had been carried out prior to the setting-up of the college and consequently staff, when they were recruited, were expected to define their own curriculum responsibilities in the new situation. The opportunity to define the nature of one's programme was seized and for the author this presented a chance *to develop a new approach to the education of secondary school mathematics teachers in Ireland.* However, by the time the author had taken up his appointment in December, 1974 the College had already been in existence for almost two years, students were well-advanced on their courses, and certain broad areas of responsibility had been established largely on the U.K. model of Colleges of Education. The curriculum acknowledged Physical Education, Education and the second teaching area designated the Foundational Subject Elective (FSE) as substantative areas of study. Students were supported in the teaching practice in their teaching areas by special courses directed unambiguously towards the teaching practice experience. These courses were designated Curriculum Studies Electives (CSE) and were designed and implemented by personnel with appropriate experience and/or qualifications in the students' teaching areas. The original list of second teaching areas included French, Music, Drama, Irish and Mathematics as separate options. The early mood seems to have been one of innovation and experimentation as evidenced by the list of options. However, the economic reality coupled with a deep concern for the employability of graduates caused the original list to be rescinded. New subject options were introduced namely Social and Environmental Studies, English and Science and Music; French and Drama were to be phased out. The College situation, therefore, while offering a high, degree of personal autonomy to lecturing staff balanced it somewhat by certain agreed conventions and principles. The author in the main operated within the general format but did not hesitate to 'bend' some rules and question some principles. The new Mathematics

Programme discussed in the remainder of this chapter was conceived in these circumstances and was written and codified for the purpose of submitting it to the degree validating body, the National Council for Educational Awards. Later a revised version was submitted to University College, Cork acting in its statutory capacity for the National University. Each programme was validated without modifications and classes have graduated from the programme in each of the years 1975-78 inclusive. A second revision[1] was prepared for submission to the validating authority in 1977 but due to external political reasons pertaining to the re-organization of third level education in Ireland, it was never actually submitted but does nevertheless represent an important stage in the evolution of the Mathematics Programme at Thomond College and as such merits inclusion here. It is the author's intention, therefore, to discuss the Mathematics Programme as it evolved through these stages.

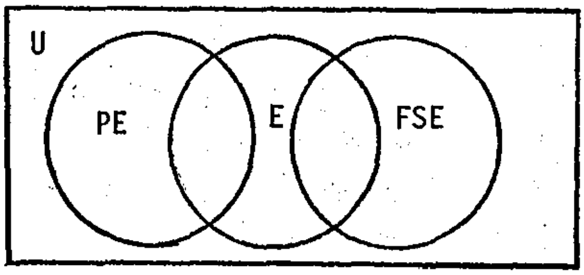
The author's approach to the problem of training mathematics teachers as the programme evolved was very much a naive one i.e. naive in the sense that mathematicians talk about a naive set theory. And much of what is now said by way of justification is post hoc in nature, rationalizing what were in many instances the intuitive gropings of the author. The pressures of impending deadlines, lack of adequate in situ library facilities and heavy teaching load prevented anything approaching systematic research while the programme was in the making but nevertheless many sources were

1. This programme will be submitted to the National Council for Educational Awards for validation in Dec. 1978.

consulted and a programme evolved which was perhaps unsophisticated but never impractical in relation to the job at hand.

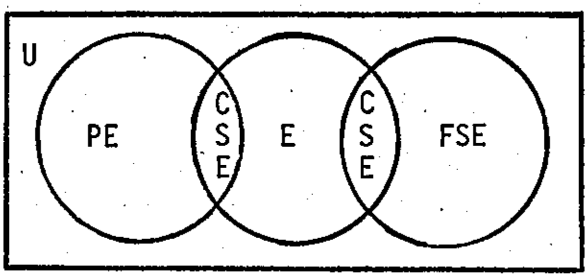
4. Thomond College - A Curriculum Overview

The College as conceived by the Department of Education was to develop along a new model for teacher training in Ireland. The principal features have already been discussed in a preceding paragraph. The general outline given here describes the College's response to those guidelines and subsequent evolution of the College curriculum. A definite pattern was already evident when the author took up his appointment in December, 1974. Although integration was an important consideration then identifiable areas in the College curriculum were plainly visi ble. Since students were expected to qualify in two teaching areas the curriculum could be viewed in broad terms as comprising Physical Education, Education, and Foundational Subject Elective as long as it was agreed to accept areas of overlap (Fig.6.1)



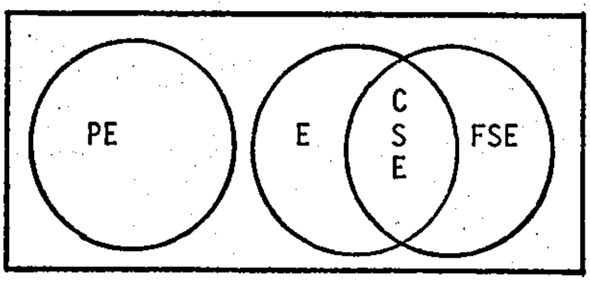
COLLEGE CURRICULUM (c.1974)
FIGURE 6.1

During ensuing years the pattern became more clearly delineated largely as the result of experience in teaching, examining and administering the programme under actual working conditions. The continuing debate within the College led to the preservation of some ideals but some suffered dilution. From an original conception of curriculum which might be accurately described as integration - schematically pictured in Figure 6.2 - the College has arrived at a position which is perhaps more appropriately described by the term 'coordination' - a diluted form of integration.



PE = Physical Education CSE = Curriculum Studies Elective
E = Education U = College Curriculum
FSE = Foundational Subject Elective

COLLEGE CURRICULUM (c.1975)
FIGURE 6.2



Symbols as in Figure 6.2
COLLEGE CURRICULUM (c. 1977)
FIGURE 6.3

It is also informative to look at the entire curriculum from the point of view of examining it for degree purposes. Since each student has to demonstrate competence in teaching, the teaching practice experience became an examination component. As part of the degree requirements students are also required to submit a dissertation (10 000 words) on an appropriate topic in Physical Education or Education or second teaching area. Thus for the purposes of degree examination the programme is divided into five components viz. Physical Education, Education, Foundational Subject Elective, Teaching Practice and Dissertation. Various schemes have been used in the past but each Marks and Standards document has dealt with the programme under these headings and ultimately each degree award to date was made on the basis of assessed performance in those areas.

The Mathematics Programme described in this chapter evolved as a Foundational Subject Elective within the institutional and curriculum constraints already described. And the mathematics teachers described as graduating from Thomond College are in fact dual teachers - they teach Physical Education and Mathematics at secondary level. Their teaching is not officially restricted or directed to any specific age group within the secondary school age band.

5. The Mathematics Programme - Initial Working Constraints

The responsibility to produce a meaningful Mathematics Programme in the context was demanding and such a project was never before attempted in Ireland. Social, institutional and curriculum considerations impinged on the activity but none of them was definite enough to serve as an anchor for the project. The consensus view within the College, and supported by the Board of Management and later endorsed by the Governing Body, that the FSE programmes be designed to prepare students to teach through the entire range of second level education in the FSE area and not just to the junior cycle provided an immediate starting point. Subsequently a brief consideration of the University situation in Ireland led to the conviction that their approach was fundamentally at variance with the enunciated philosophy of NCPE (later Thomond College) in several important ways: (1) University teacher training was consecutive i.e. subject degree course followed by the Higher Diploma in Education; (2) the University degree course was designed to produce mathematicians and not teachers of mathematics ; (3) students may or may not be committed to teaching from the outset. Thus the University as a model was ruled out on the basis of these considerations which when analysed more closely led to the conclusion that the university approach was unsuitable organizationally, motivationally and content-wise. Freed from the constraints of the traditional university approach to the training of mathematics teachers in Ireland new possibilities became apparent. Instead of looking to the Universities it was deemed more appropriate to concentrate on what was happening in school mathematics, specifically contemporary developments in Irish schools. *Thus the entire programme was conceived and subsequently justified as a response to the school situation in Ireland and is unique in Ireland in that respect.* But therein lay another constraint, the programme was developed as a response to the contemporaneous needs of secondary school mathematics teachers *and their future needs* and therefore of necessity had to equip the students to handle the teaching of a single nationally implemented school syllabus in secondary school mathematics. Their ability to do so and in a *better* fashion than previously accomplished in Irish schools would no doubt be used as a measure of success of the programme although not the only measure.

6. Programme Philosophy

The vagueness of demarcation lines between programme aims and goals is generally acknowledged, and meaningful discussion is therefore possible. It is, however, no less difficult to distinguish between aims and goals on the one hand and programme philosophy on the other. One no doubt is born of the other in the educational and social milieu but who can clearly define the order? Bearing this in mind the following paragraphs are offered as an elaboration of the programme philosophy and it is difficult in retrospect to distinguish between ideas which were there at the outset and as the programme evolved from those ideas and principles which have since become fully integrated into one's own thinking. The term 'programme philosophy' as used here, therefore, refers to the ideas and principles which shaped the programme as it evolved in the period December 1974 - September 1977, ideas which are now more clearly fixed after some years of study and internal dialogue and the need to articulate them clearly for personal clarification and the clarification of non-mathematics colleagues and validating bodies.

In modern times an educational philosophy must show cognizance of important psychological developments since many aspects of psychology have direct bearing on the learning and teaching situations. This is nonetheless true of the educational philosophy of a mathematics programme. Such a philosophy must provide a framework in which certain personal and explicit subject-oriented goals can be attained and contain the genesis of a system for attaining these goals [93]. In the teacher training context the attainment of professional aims must also be possible and probable. If the educational philosophy provides a synthetic concept fabric in an acceptable environment which expedites teaching and learning then it is acceptable. And while an educational philosophy necessarily invites students of the programme to share in a certain vision of the subject area and content it must also develop in the student discriminating powers which enable him to adopt and indeed construct an alternative vision if he so desires. The educational philosophy of this programme is based on the psychologists' explanation of man interacting with his environment, an interaction which places his existence in a general problematic context in which progress inevitably involves the solving of problems. To the extent that this activity has been systematized using modelling processes it becomes fertile ground for the development of mathematics.

The vision of mathematics which informed and continues to inform the Mathematics Programme at Thomond College is that of a thoroughly human activity permeating all human affairs. Mathematics is a monumental achievement of the human intellect and to date has contributed enormously to man's well-being. It has enabled man to come to grips with his environment by greatly enhancing his problem-solving capability. As to why this is so no one really knows, but it has led to vigorous debate and active research into the foundations and nature of mathematics. Mathematics is many things for different people including mathematicians but no one denies its proven record in problem-solving and its vast and as yet unexploited potential for problem-solving in every sphere of human activity. The Mathematics Programme focusses on this fundamental aspect. In simplistic terms man interacts with his environment. His environment has been problematic for man from the beginning and continues to be so. He responds to it on many levels; on the level of sense experience and on an intellectual level. Mathematics can be seen as a very powerful intellectual response. Much is known from a psychological point of view about the way man interacts with his environment. Problems arise because man is motivated and motivations are objectives-seekers. But there is usually some obstacle to the attainment of the objectives. Thus a problem in a broad sense may be described by the simple recipe: problem equals obstacle plus objective [94]. On a psychological level mathematics can be viewed as a development which accompanies the problematic nature of the interaction of man and his environment. More specifically and according to psychologists man copes by recreating his environment through a process of modelling [95],[96]. All kinds of situations are modelled in the continuous experience of living. Mathematical modelling is a specialized type of modelling and is inextricably intertwined in the general problem-solving activity. The use of these ideas shaped the programme around the general problem-solving theme and mathematical modelling. The mathematics input is designed to develop an appreciation of the problem-solving activity, its basis in the human condition and its implications for Science. *Mathematical* *modelling is taught and presented as a rationale for the use of mathematics in Science.*

Many advantages accrue from these considerations. This approach allows for developments *in* and applications *of* mathematics. The mathematical requirements of models may be viewed as generative of more sophisticated mathematics. This provides a rationale for developments within the mathematics programme. The problem-solving activity itself may be viewed as a powerful generative feature of mathematics and offered as a credible factor in the development of mathematics as a corpus of knowledge. The mathematics/science interface is adequately explained in terms of the problem-solving/modelling activities.

Obviously the way in which one fits Mathematics into *his* world view has important implications for teaching. The consequences are significant on at least two levels: (1) the student-teacher's view of mathematics is greatly influenced by his College experience which in turn is organized along certain lines consistent with the programme developer(s) views; (2) at school level it is the teacher's vision of mathematics which shapes the mathematical experience of children. However, student-teachers and *their* teachers must revise and modify their vision in light of subsequent personal development. It is implicit therefore, in any programme of teacher education for mathematics teachers that student-teachers develop the means of integrating mathematics into their world pictures. Consequently it is necessary for teachers of mathematics at *all* levels to possess a synoptic view of mathematics, be acquainted with its history and foundations, value the scope of great ideas in mathematics and sense wherein they are important, and appriciate the role of mathematics in the human condition. May [97] put it succintly when he asked:

> "How can we expect teachers to plan a curriculum, choose texts, explain mathematics to their colleagues and to parents, or to give a sound picture of it to their students, unless they have some knowledge and experience of the history and philosophy of mathematics and its role in contemporary culture?

A basic premise on which the whole programme hinges is the conviction that mathematics plays an important role in society; an important role which impinges upon the individual in his daily living. This view derives largely from the fact that the world as it is today (or likely to be in the forseeable future) is permeated by the effects of science and technology which are untelligible without some understanding of mathematics. Hence every person needs some mathematics to cope with the world in which he lives. The goal of mathematics teaching, therefore, must be to inform and educate pupils for life in society. Consequently teachers of school mathematics must be helped towards a rounded, humane and comprehensive view of mathematics and its place in society. And in Lighthill's view [98] *"The planning of mathematics education needs to take into account the interaction between mathematics and society"*.

This view of mathematics is utilitarian but its usefulness to pupils as future members of society is measured not only or principally in terms of a narrow interpretation of 'useful' as used to justify courses such as Social Arithmetic and the like, but mainly in terms of its power and elegance in organizing our experience [99]. This attribute enhances the position of man vis-a-vis his environment by equipping him with the intellectual tool par excellence for controlling his environment. Merritt [100] has said in defence of teaching personal management skills via a generalized problem solving routine: (p.9)

> We are concerned with *all* the ways in which a person can be helped to achieve his own continuous development as a person in the fullest sense. We must take every aspect of human existence as needing attention and being worthy of attention... Everyone has many rich and complex roles to play if he is to be effective in managing his own affairs in the long run as well as in more immediate respects. Each of these needs to be fully explored.

The management of one's own affairs in modern society is becoming increasingly dependent upon an adequate command at an appropriate level of the major conceptual categories used to organize modern society namely, those peculiar to Science and Mathematics. Such knowledge may not of itself be sufficient for the task but it certainly is necessary if the individual's role is to be more than that of spectator. However, the emphasis must be on the development of mathematical 'know-how' as opposed to learning fixed bodies of content in mathematics [101]. Willoughby [102], insists that "the ultimate goal of mathematics education for most children is to make the mathematics useful to them in some sense, but the method of achieving this goal is not entirely clear" (p.274).

The insistence on the twin motifs of problem-solving and mathematical modelling throughout the programme demanded an *organic view* of mathematics [103]. The principle that mathematics should be presented not just analytically, not just numerically, not just statistically but as an organic whole demanding at any instant a knowledge of any one or all of the above approaches, informed the *teaching* of the programme. One cannot preach such a doctrine and expect people to follow; it requires teaching by example i.e. student-teachers must learn this from a teacher who practices it. The value of this approach is that: (1) it more accurately represents the ways in which mathematics is actually used to solve *real* problems; (2) it brings a whole range of mathematical expertise to bear in any instance, an important consideration since many problems which are not amenable, say, by analytical means are amenable to solution by numerical and/or statistical means;(3) and therefore has distinct motivational and pedagogical advantages because it *does* depend upon the treatment of real problems.

7. Aims and Objectives

From the start the aim of the Mathematics Programme has been unequivocal, and it has remained undiluted in subsequent revisions. *The programme aims at bringing students to a level of competence in mathematics which will enable them to be effective teachers of mathematics through the full range of second level education in Ireland.* The goal i.e. effective teachers of mathematics is the overriding consideration here. A feature of programme design and philosophy ensures that successful students are also competent to teach General Science in the Junior Cycle i.e. up to the Intermediate Certificate Examination, but this aim is a subordinate aim of the programme. The pursuit of such an aim became desirable and administratively possible when FSE Mathematics was enveloped under the FSE Science umbrella in 1975. While such an arrangement was necessary from the purely practical point of view of the viability of FSE Mathematics and FSE Chemistry, its implementation was not at variance with the programme philosophy. The view taken and subsequently acted upon was that Mathematics teachers can gain considerably from a background in Science with beneficial consequences for their mathematics teaching.

It must be appreciated that the programme implicitly aims at educating *teachers of mathematics* and not *mathematicians*. The fundamental distinction hinges on the fact that the personal and professional requirements of teachers in training differ significantly from the requirements of mathematicians in the making. To be a teacher of mathematics in secondary schools it may be sufficient to be a mathematician but is certainly not necessary. It is true that the future teacher of mathematics must develop his mathematical expertise to a certain level by studying mathematics well beyond that which he must teach. However, since his future requirements differ from those of the mathematician the context, scope and rigour will be quite different. In addition the future mathematics teacher is concerned essentially with mathematical education, a set of related activities which is not strictly speaking a subset of mathematics. It includes by definition knowledge and results from other disciplines such as Education, Psychology, Sociology and History to name but a few [104]. The point is pursued further by Niss who states that: [105].

> Among the most important qualities for a teacher in mathematics is that of being able to *arrange any teaching situation in such a varied way as to pay attention to the particular social and intellectual background of the individual student.* This implies that the teacher must be able to pursue - also from a professional point of view - the same objectives in different ways, on the basis of pedagogical/psychological and didactic reflections on the actual situation.
>
> In order to be able to carry out such an instruction the teacher must be educated according to principles different from the current ones. He must have gone through an education where he himself has acquired experience of problem-oriented work on mathematical models and with problem-directed selection and learning of mathematical theories and methods.

Niss contrasts the altered education of mathematics teachers described above with the existing education in his country, Denmark namely the education of mathematicians as such. It is clear, therefore, that future teachers of mathematics who are educated in Colleges of Education must be treated differently from future mathematicians who are found elsewhere. An important conclusion derives from these considerations i.e. students who enter Colleges of Education for the purpose of becoming mathematics teachers must be treated as *non-mathematicians* and educated accordingly.

The stated objectives of the programme were revised when the programme was readied for resubmission to validating bodies. These revisions did not constitute any fundamental change in the objectives but were rather a matter of making certain implicit objectives *explicit*. Experience of the programme under actual conditions led to the crystallization of certain previously unspecifiable assumptions which were subsequently given priority according to their merits, and formulated as worthwhile objectives. The spirit of the programme is perhaps best exemplified in the list of objectives set out in the second revision of the programme which includes: [106].

- To cultivate and foster in students the ability to think mathematically
- To promote breadth and depth in mathematical content with due emphasis on the acquisition of skill in the use of mathematical techniques
- To cultivate a structured approach to problem solving especially as this activity relates to applicable mathematics
- To equip students with knowledge and understanding which goes well beyond the scope of that which is expected to be taught
- To develop in the student a worthy sense of the meaning and scope of great ideas in mathematics
- To equip students with a mathematical background in which future personal mathematical development is possible for the student
- To promote a world picture in which mathematics is seen as a human activity deriving meaning in the context of man and his society
- To provide students with experience of a mathematics programme which is functional in relation to the school situation.

The basic assumption underlying the programme is that successful students i.e. students who have attained these objectives will perform effectively as secondary school mathematics teachers in Irish schools.

These then may be viewed as constituting *necessary* and *sufficient* conditions i.e. a student who has attained these objectives will be an effective teacher of mathematics *and* an effective teacher of mathematics will have attained these objectives. Consequently the Mathematics Programme at Thomond College is designed to maximize the students' chances of attaining the stated objectives.

The rationale behind the objectives is important. The ability to think mathematically is a prerequisite for meaningful activity in mathematics. On the assumption that mathematics instruction constitutes meaningful mathematical activity then teachers of mathematics who are mainly responsible for providing instruction in mathematics should themselves be able to think mathematically. On another level the ability to think mathematically is essential before real benefit can be gained from individual courses and the programme as a whole. It is a rudimentary skill which is *developed* by use in the different activities of the programme but which also *contributes* as it develops to a better mathematics experience, an important factor in the personal and professional formation of a future teacher.

There is an obvious need for breadth and depth in content since without this no true insights can be possible and the would-be teacher suffers from a dearth of relevant mathematical experiences. The initial undergraduate experience of the student-teacher must take the student well beyond that which he is expected to teach [107]. The programme defines what 'well beyond' means in this context since what is to be taught by the future teacher is available for scrutiny in the form of an official syllabus. However, this aspect is complicated by the fact that a student-teacher cannot hope to enter into a permanently static school situation and therefore, what is well beyond what he teaches today may fall far short of his requirements for teaching in the not too distant future. Consequently his undergraduate mathematical experience must provide the basis for future development so that he may be capable of an adequate response in a changing and changed situation. Such considerations require adequate, reasoned and explicit responses from the students' mentors, responses which *must* contribute and influence the programme design and teaching.

The attainment of a refined problem-solving capability is considered a sine qua non for realizing *all* other programme objectives. The fundamental position of problem-solving in the programme is thereby underlined. Such a stance is justified by: (1) the importance of problem-solving in the human condition and; (2) the role of problem-solving in teaching and learning mathematics. To paraphrase Polya [108] to know mathematics is to be able to *do* mathematics but among all the ways of doing mathematics solving problems stands out as the 'most cardinal mathematical activity'. The social and cultural aspects of mathematics are further promoted by insisting on the study of the history and nature of mathematics with a view to developing an appreciation of mathematics as a human activity deriving meaning in the context of man and his society [109]. Such activity is also calculated to develop a worthy sense of the meaning and scope of great ideas in mathematics. The Mathematics Programme as planned and implemented is an *appropriate environment* and constitutes *adequate means* for the attainment of the objectives. The concrete details of the curriculum derive from the above objectives.

8. Programme Description and Organization

It is the end result of the metamorphosis of the Mathematics Programme over a period of three years which is described here. The programme has been phased into operation during this period with different classes being exposed to different forms. Certain of the original aspects were consolidated and others extended after experience with the programme. The initial programme was aimed at the class graduating in 1975 and mathematics content was a priority. Nevertheless due care was taken with such essential matters as programme philosophy and aims. The whole mathematics curriculum then was telescoped to fit a foreshortened time schedule. With only two terms and a special summer term available the content was trimmed to bare essentials. Operating within a more relaxed time schedule for the class graduating in 1976 more desirable content was included expanding the programme somewhat in the process however, the structure remained unchanged. The first revision was prepared during this period and the structure of the programme changed to include science courses in each of the first two years, followed by mathematics courses over the next two years. Students graduating in 1977 and 1978 followed an abridged form of this first revision. A second revision was completed in 1977 and it is envisaged that the present second year group will graduate under the terms of the second revision. And so far as is possible students in years three and four will conform to these conditions.

The author enlarged his area of activity in direct response to the demands of the Mathematics Programme. In order to guarantee the integrity of the programme it was necessary to take certain steps. Presently the author discharges his responsibility by planning and coordinating the overall programme, overseeing and in some instances generating and teaching the Curriculum Studies courses and engaging in teaching practice supervision of students in schools. The author is solely responsible for the mathematics content, aims, objectives, organization and structure of the whole programme and claims no other rights in relation to the programme. For that reason the description of the programme is concerned principally with the structure of the programme and the mathematics courses per se.

The essential features of the Mathematics Programme are:

- Mathematics content
- Science content
- Practice Teaching
- Curriculum Studies
- Education Studies

These features are integrated and concurrent in the four-year programme. With the exception of science courses which end after two years all areas are studied in each of the four years. The mathematics and science components need no special justification for their inclusion in a programme of training for mathematics teachers. Education Studies is an area common to all students in the College regardless of their elected second teaching area. All teachers obviously need General Education courses and therefore from a mathematics point of view such studies are essential for the professional formation of the teacher and in specific ways are identifiably supplementary and complementary to the needs of mathematics teachers e.g. study of curriculum and assessment. The Curriculum Studies and Practice Teaching have been identified in the list not because they are held to be different from Education Studies but because in relation to the Mathematics Programme they play a special role. The Curriculum Studies element is important since this is where the theory and practice of mathematics teaching is studied and coordinated in classroom and workshop sessions. Each mathematics student gains supervised school-based teaching practice experience in mathematics.

An overview of the programme which was validated by University College, Cork in 1977 for the National University is presented in a semi-pictorial way in Figure 6.4 and Table 6.1 gives the hour content. Figure 6.5 illustrates the general organization of the programme content-wise. Tables 6.2, 6.3 and 6.4 give respectively for Mathematics, Science and Curriculum Studies details of courses, year taught, title and duration in hours. And lastly, Table 6.5 supplies details for teaching practice.

9. Factors governing the choice of Mathematics content

It is obvious that details of the curriculum should derive from educational goals and programme objectives [108]. However, it is not always obvious that such is the case. The Mathematics Programme at Thomond College was subjected to close scrutiny in the making and during its evolution with a view to arriving at a situation where it could be seen that every aspect of the programme as it was implemented was related to the programme aims and objectives. *The aims, objectives and syllabuses were set out clearly and were available for scrutiny and criticism - something novel in the Irish context.* Such organization and explicit statements were necessary because the programme was breaking new ground educationally in Ireland, and in anticipation of the need for explaining and justifying the programme to students, colleagues and validating bodies.

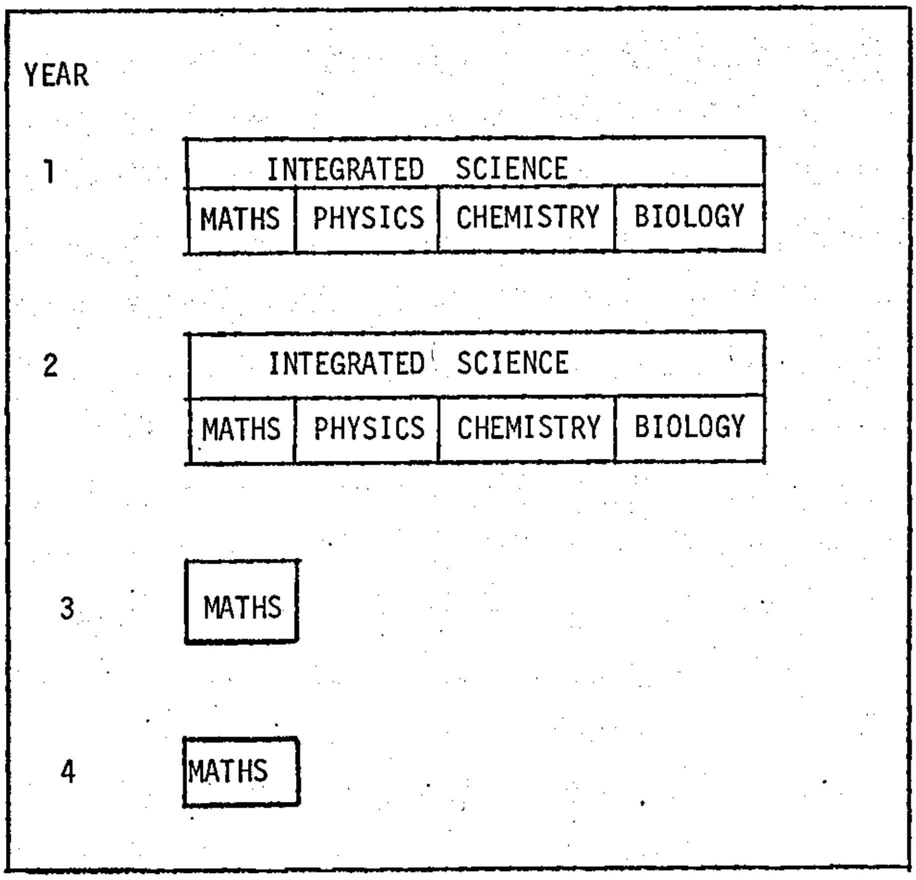
YEAR	STUDIES	TERM 1	TERM 2	TERM 3
1	MATHEMATICS	ONE HOUR LECTURE PER WEEK		
	SCIENCE	LECTURE/TUTORIAL/LABORATORY SESSIONS		
	CSE	ONE HOUR LECTURE PER WEEK		
	TP			3 WEEKS
2	MATHEMATICS	ONE HOUR LECTURE PER WEEK		
	SCIENCE	LECTURE/TUTORIAL/LABORATORY SESSIONS		
	CSE	ONE HOUR LECTURE PER WEEK		
	TP		5 WEEKS	
3	MATHEMATICS	TWO THREE-HOUR COURSES PER WEEK		
	CSE	LECTURE/WORKSHOP SESSIONS		
	TP		5 WEEKS	
4	MATHEMATICS	TWO THREE-HOUR COURSE PER WEEK		
	CSE	LECTURE/WORKSHOP SESSIONS		
	TP		5 WEEKS	

MATHEMATICS PROGRAMME OVERVIEW
FIGURE 6.4

TABLE 6.1

MATHEMATICS PROGRAMME : HOUR CONTENT

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
MATHEMATICS	30	30	155	155	370
SCIENCE	176	170	-	-	346
CSE	27	25	43	25	120
					836



MATHEMATICS PROGRAMME : GENERAL ORGANIZATION OF MATHEMATICS AND SCIENCE CONTENT

FIGURE 6.5

TABLE 6.2

MATHEMATICS PROGRAMME : MATHEMATICS CONTENT

YEAR	COURSE TITLE	HOUR CONTENT
1	FSE Mathematical Methods 1	30
2	FSE Mathematical Methods 11	30
3	FSE Calculus	60
3/4	FSE Ordinary Differential Equations	30
3/4	FSE Algebraic Structures	30
3/4	FSE Linear Algebra	30
3/4	FSE Transformation Geometry	30
3/4	FSE Graph Theory	30
3/4	FSE Statistics and Probability	30
3/4	FSE Computer Studies	30
4	FSE Mathematics Seminar	30
		360

TABLE 6.3

MATHEMATICS PROGRAMME : SCIENCE CONTENT

YEAR	COURSE TITLE	HOUR CONTENT
1	FSE General Physics 1	56
1	FSE General Chemistry 1	60
1	FSE General Biology 1	60
2	FSE General Physics 11	50
2	FSE General Chemistry 11	60
2	FSE General Biology 11	60
		350

TABLE 6.4

MATHEMATICS PROGRAMME : CURRICULUM STUDIES CONTENT

YEAR	COURSE TITLE	HOUR CONTENT
1	Science Teaching Methods	10
1	Primary School Curriculum	10
1	Historical Development of Science in Schools	5
2	Mixed Ability Teaching in Science and Mathematics	5
2	Science and Mathematics Projects	5
2	Preparation for Teaching Practice	10
2	Analysis of Teaching Practice	5
3	Psychology of Scientific and Mathematical Learning	10
3	Curriculum Development and Planning in Science and Mathematics	10
3	Preparation for Teaching Practice	10
3	Analysis of Teaching Practice	5
4	Assessment and Sequencing	10
4	History of Science and Mathematics	10
4	Science in Relation to total Curriculum	5
4	Preparation for Teaching Practice	10
		120

TABLE 6.5

MATHEMATICS PROGRAMME : SCHOOL-BASED TEACHING PRACTICE

YEAR	TERM 1	TERM 2	TERM 3	TOTAL
1			3 Weeks	3
2		5 Weeks		5
3			5 Weeks	5
4		5 Weeks		5
				18 WEEKS

The challenge as interpreted was to develop a Mathematics Programme which was at once comprehensive and functional, contemporary yet forward-looking, applications oriented yet not shallow. That the programme is comprehensive is self-evident (see Appendix B) and its functionality in relation to the school situation is readily verified. The programme addresses contemporary problems in mathematics teaching by ensuring that graduates are proficient in modern mathematics and literate in numerical methods. It is forward-looking in that it anticipates developments in the school situation as evidenced by the introduction of such courses as Linear Algebra, Computer Studies and Graph Theory. Numerical methods and applications of theory form an integral part of the programme as taught and are used to introduce new concepts and reinforce old ones. Understanding is stressed as the best possible preparation for applications. This is in keeping with similar trends in the U.K. which boasts such programmes as School Mathematics Project, Mathematics for Engineering and Industry and the Sixth Form School Mathematics Project. Widespread curriculum change along these lines could hardly be expected here in Ireland, nevertheless the motivation behind such change in the U.K. and elsewhere has implications for the training of teachers everywhere. In addition the programme endeavours to develop an attitude and an approach to mathematics which makes redundant the artificial division between theory, numerical methods and applications.

In the interests of coherence and consistency criteria for judging the acceptibility of mathematics content in the programme were established. These were applied to whole courses and to component parts of individual courses. They include:

- Internal relevance
- Applications value
- Functionality

In a programme it is not easy to break-off development and doing this in an arbitrary way is less than satisfactory. Certain courses need to be included for logical development and consistency and the same applies to topics within courses. For example, the programme aims at developing a synoptic view of mathematics. By this is meant the ability to draw strands together from various courses and develop themes. This requires the use of unifying concepts and generalizations, material that must be included somewhere. Since it is mathematical structure that is important in such considerations a full course on Algebraic Structures was included. In a similar way in a programme such as this one could not countenance a treatment of the derivative without some work on limits. The value of courses and topics within courses was also judged in light of possible applications both within mathematics and in other areas e.g. Physical and Social Sciences. Functionality is that criterion which guaranteed that what was being done was relevant to the school situation. These criteria, though not unique in themselves, were nevertheless important precisely because they were formulated explicitly and consciously applied and consequently served as fixed markers in an uncharted area.

At this level of discussion three courses deserve special consideration viz. Computer Studies, the Mathematics Seminar and History and Nature of Mathematics. At the beginning of 1975 when the programme was initially submitted for validation to the National Council for Educational Awards the proposed inclusion of Computer Studies in a programme of initial training for mathematics teachers was still novel in the Irish context. Several important reasons contributed to the inclusion of such a course in the programme. In retrospect it is difficult to give priority of place to some reasons over others. However, the reasons themselves are worthy of attention.

A discernible trend in school mathematics in developed countries towards some form of computer education could not be ignored. Already by 1975 several examinations boards in the U.K. had accepted syllabuses for examination e.g. East Anglian Examination Board (C.S.E.) West Midlands Examinations Board (C.S.E.) and Oxford Local Examinations (A-level). Some A-level courses notably MEI and SMP involved some programming. Computer education in various forms was gaining recognition in secondary school syllabuses in many countries with some countries introducing such subjects as 'informatics' at lower levels[110]. In Ireland too, teachers were being awakened to the need for and advantages of some computer education for their pupils. This awareness was largely the result of Professor Bajpai's initiatives and indefatigable efforts in Ireland. His pioneering efforts in this field in Ireland were anchored in his short summer courses conducted annually from 1971-1975 for secondary school teachers at University College, Galway. These courses were aimed at *all* teachers and not just mathematics teachers. Arising out of these courses which constituted the only forum for discussion of computer education in Ireland at the time, the Computer Education Society of Ireland (CESI) was formed in 1973. Some experiments in schools had been conducted and supported from Loughborough University by Professor Bajpai and these activities continued under the aegis of the Computer Education Society. The Society's main aim is the promotion of computer education in Ireland particularly in post-primary schools [111].

Since its inception in 1973 the society has been active and engaged in a variety of projects. Probably the most significant aspect of the society's work to date is its activity in training teachers. The society's annual summer course for teachers has always been well subscribed and is usually supported financially by the Department of Education. Many teachers have introduced computer education into their schools as a voluntary after-school activity and have been supported materially by the society with advice and help with key-punching and processing. Some few secondary schools have installed equipment. All this activity is directed towards gaining official recognition for a computer education syllabus to be implemented in Irish Secondary Schools. A draft syllabus was submitted by the Society to the Department of Education for consideration in 1975. Since the submission of such a syllabus marks a milestone in computer education in Ireland it is set out in Appendix C. This society continues to work for computer education in schools but the principal obstacle to progress at present is not specific official opposition to computer education per se but rather a conservative stance towards the financial implications of implementing computer education in schools.

While external trends in schools mathematics and internal pressures contribute significantly to curriculum change and the direction it takes, other factors are also at work. Being *fashionable* is simply not a sufficiently compelling reason for changing the mathematics curriculum. If there is no real sense of the *worth* of innovations then it is questionable whether any gains accrue from such innovations. Therefore, it is necessary and desirable to justify the inclusion of computer studies in a programme of teacher education for mathematics teachers. Basically a course in computer studies is warranted because of the "need for all children to know something of the nature and uses of computers in modern society"[112]. This need is the inevitable consequence of the increased influence of computers on society at large, an influence which has implications for the curriculum of secondary schools. The proposition is that *all* teachers require some computer education and therefore *all* teacher education programmes must make adequate and appropriate provision for computer education. From the point of view of a future mathematics teacher the role of the computer is highly significant in his own personal education. Perhaps the most significant aspect is the potential for developing a well-articulated generalized problem-solving routine and the accompanying attitude towards solving problems [113],[114]. Here, one is especially concerned with the advantages to be gained from an explicitly stated problem-solving technique and its implementation, and from the disciplined logic required to effect solutions involving the use of flow charts. In the computer context this is what is meant by 'programming' as opposed to 'coding'. It is fundamental to this position that any course in computer studies for teachers especially teachers of mathematics provide for programming experience. As Moriguti [115] puts it "A study of computers must start with programming. It is only through programming that one gets a good insight into the field of Computer Science and computer applications" The Computer Studies course offered in the Mathematics Programme at Thomond College is based on the concept of appreciation by doing and hence the importance of programming. The essence of this position is encapsulated by Jackson and Smith [116]:

> It is our belief that an introduction to computer programming should be an essential part of all *appreciation* courses. There

are two main reasons for this:

1. Often the use of an already written program may involve some quite sophisticated operations on the part of the user; e.g. creating a data file, inserting data into programs, or even amending the programs in some way. An understanding of programming would certainly help the user in carrying out these steps.

2. More importantly, perhaps, an elementary understanding of programming can help the user become aware of precisely how the computer is being utilized, and leading on from this, come to appreciate how applications may be extended in the student's own subject area.

[my italics]

In addition the course is fundamental to the whole programme since it is structured in such a way as to complement and supplement the problem-solving activity of the student. The emphasis is on programming and applications packages and in this way is an integral part of the programme. The Computer Studies course is discussed at length in Chapter VII where it is central to the discussion on Personalized Systems of Instruction (PSI) and the use of PSI in Thomond College. Suffice it to say here that the spirit of the Computer Studies is best described by the words of Wiechers[113]:

> To summarize: programming teaches a student to develop models; it also teaches him that a model must be tested by providing input and producing results. In trying to obtain results that are correct, the student must critically examine his model, and thus gain a deeper understanding of the situation the model represents. *Not only does a student of programming improve his general ability, but learning to program provides him with a thinking attitude not easily gained from any other discipline.*
>
> [my italics]

Obviously such sentiments provide many interesting possibilities for the mathematics education <u>per se</u> of the student in the potential for dealing with *real* problems and extending the range of techniques available by admitting numerical and statistical analysis and extending computational capability generally. This, then is easily reconciled with the programme objectives since it contributes to the development and treatment of mathematics as an organic whole.

It has already been said that the cultivation of a synoptic view of mathematics in the teacher was viewed as essential to the attainment of the programme objectives. Unlike Computer Studies which figured in the programme from the beginning, there was initially no specific course designed to cultivate the perspective implied by a synoptic view of mathematics. It was considered sufficient to point out recurring structures as they arose in different courses and to mention unifying concepts in the various introductions to courses and topics. This approach proved unsatisfactory for the obvious reason that students were not actively participating in the development. Upon further reflection and after a little more experience a deeper penetration of problem showed the necessity not only of developing the concepts required but co-importantly, developing the concepts well enough to form the basis for verbal articulation of the position. This realization pointed to the need for a special forum for this verbal activity and the preceding groundwork. A Mathematics Seminar was instituted for that purpose and was included in the first revision of the programme. Three different formats have been employed in the seminar with different graduating classes. The first attempt was based on short talks by the lecturer on specific topics chosen for their unifying or generalizing potential. The talks were followed by group discussion. The second format attempted to get students more involved by assigning topics for preparation by students. Each student then reported to the group and there followed a short discussion. The most recent attempt was structured around a file of selected readings related to individual topics. The student was expected to make a precis of each pertinent paper and keep it in a file and to present an essay (500 words) on a set topic related to the file. In addition, the lecturer delivered a series of occasional lectures, five in all. The 'mechanics' of the latest course were described in a hand out as follows:

THOMOND COLLEGE OF EDUCATION

COURSE : MATHEMATICS SEMINAR TERM: 1, 1977
TUTOR : J O'DONOGHUE DURATION: (3x10)hrs equivalent

COURSE OUTLINE AND REQUIRED READINGS

1. J O'DONOGHUE will give a series of occasional lectures on selected topics. Students will be advised as to topic, venue etc in due time.

2. (a) Each student is responsible for reading each article on the list of selected readings

   (b) Each student is responsible for writing a short summary (½ page) of each article, maintaining summaries in a file which must be available for scrutiny by the tutor.

3. (a) The readings were selected so as to facilitate the development in the student of a synoptic view of mathematics.

   (b) The following themes lend structure to this endeavour

   (i) Problem-solving
   (ii) Mathematical Modelling
   (iii) Mathematical Structures
   (iv) Mathematical Knowledge
   (v) Proof techniques and the nature of mathematical proof.

4. ASSESSMENT is based on the following course elements:

   (i) Attendance at occasional lectures
   (ii) Article summaries
   (iii) Short (500 word) essay on the following topic:

(iii) contd...

Identify major themes running through your mathematics programme and use these themes to effect a unification of the programme as a whole.

The results of such efforts have in every case been disappointing as measured by performance on a special examination paper in the degree examination. However, the objective is considered so important for teachers of mathematics that more effective ways of achieving the objective have been sought.

The kind of perspective implied by a synoptic view of mathematics is dependent upon many complex factors. It depends ultimately on a good grasp of mathematics content but breadth and depth in treatment is essential since the student must have sufficient experience on which to base a synoptic view. Such a view cannot be achieved without an adequate understanding of the genesis of mathematical ideas and their evolution i.e. it is only through its history that mathematics can be properly understood and placed in context [117]. It is in this connection that history of mathematics courses were first given serious consideration at Thomond College. A token effort in the Curriculum Studies area was deemed inadequate and inappropriate and a greater commitment to history of mathematics *as an important content course in mathematics* developed. Three short courses in the history of mathematics were included in the second revision of the Mathematics Programme (see Appendix D) as content courses. This represented a major commitment to the history of mathematics in the programme. The author feels that the most difficult thing that teaching has to do is to give an appropriate sense of the meaning and scope of a great idea. Such an objective cannot be achieved without an historical perspective.

There is no doubting the fact then that the primary reasons for introducing history of mathematics courses into the programme were linked with *cultural arguments*. The programme seeks to accomplish many things which can be interpreted as cultural. Wilder [118] states that:

> ... the standpoint from which I believe we should present the history of mathematics is at an even higher level than mathematics. By this I mean, to take a broad view of mathematics as a living, growing organism which is continually undergoing evolution; in short, we should study it as a culture.

Such a view is entirely in keeping with the objectives of the Mathematics Programme at Thomond College and further, the teaching of the history of mathematics is projected along the lines set down by Wilder [118] namely "as a flow of concepts and ideas in the large".

While the inclusion of history of mathematics courses in the Mathematics Programme can be justified on strictly cultural grounds it was also felt that there were serious implications for a *teacher education* programme. Schaaf [119] has said that:

> It has long been my firm conviction that no teacher can do his most effective and creative work without an adequate understanding of the historical development of the subject which he teaches. If so, this may perhaps be even more true for mathematics than for other disciplines.

This view has been embraced at Thomond College and informs the Mathematics Programme there. On another plane the actual teaching of the mathematics to student teachers is facilitated in a variety of ways. The perspective afforded by an adequate understanding of the history of mathematics contributes to a better understanding of mathematics. An understanding of the history of mathematics provides an alternative approach to the teaching of mathematics in a strictly logical fashion using instead a historical sequence [120]. This approach not only illuminates but perhaps more importantly *motivates* students. There is much to be said for an historical approach to the teaching of mathematics especially at second level and this view is confirmed by many eminent mathematicians including Polya, Kline and Sawyer [101]: "On the whole we may expect greater success by following suggestions from the genetic principle than from the purely formal approach to mathematics". Very often the significance of great ideas or indeed an appreciation that ideas are great can only be developed against a backdrop of history. In this context, one is referring to such familiar concepts as the coordinate plane which few students ever appreciate as a concept which represents a milestone in the development of mathematics. History can help here. Jones [121] referring to the uses of historical materials has summarized them into three broad categories:

> (1) they may clarify meanings, give insights, and sharpen understandings of mathematics itself; (2) they may give students desirable "appreciations"; and (3) in addition to contributing directly to the achieving of such desired outcomes as mathematical understandings and appreciations, they may also serve as primarily a pedagogical device for improving instruction, that is a methodological tool.

It must not be inferred from these statements or the organization of the programme that history of mathematics should be treated *only* in a history of mathematics course. While it is important for the reasons mentioned for teachers of mathematics to study history of mathematics it is perhaps equally important for a teacher of teachers of mathematics to introduce historical material into all content courses in mathematics and this has been a feature of the Mathematics Programme even before specific courses in the history of mathematics were introduced. The view taken at the time is encapsulated in the remarks of Seltman and Seltman [122]:

> For it is the teacher's understanding, awareness and knowledge of the historical development of mathematics its origins and connections, internally and externally which must be skilfully distilled and intermingled, implicitly and explicitly were necessary and possible, in the course of performing his central and predominant task of developing the student's understanding and ability to solve problems.

Seltman and Seltman [122] hesitate to recommend the teaching of history of mathematics as a formal subject. The position adopted at Thomond College is that in the *education of teachers of mathematics* both the formal and integrated approaches are necessary and complementary. The integrated approach preceded the other at Thomond College where the mathematics teaching has been deeply involved with developments in mathematics as they foreshadowed particular concepts. Biographical data on famous mathematicians was injected into normal courses and recurring themes were identified and highlighted. Perhaps the best way to describe the present attitude to history of mathematics at Thomond College is simply to repeat the words of Grattan-Guinness[123] "History can be substantially employed in the training of teachers, but has to be diluted or 'saturated' for pupil consumption."

10. Programme Evaluation

It was accepted from the beginning that the aims and objectives and the attainment of desired abilities and skills had implications for *teaching* and *assessing* the programme. The objectives might better be achieved by choosing different teaching methods and differing means of assessment [124]. The concern for different teaching styles was evident from the beginning since different teaching methods were consciously planned for different courses. The underlying rationale was that (1) certain abilities and their development required different approaches and (2) teachers in their own experience should experience different teaching styles first hand. The latter point can be understood in terms of benefits to the student-teachers own learning of mathematics allied with the fact that it was considered important for student-teachers to experience certain teaching methods as a prerequisite for their implementation at a lower level.

The whole programme was continuously assessed by means of various instruments chosen for their appropriateness to the course, objectives and teaching methods. Courses were taught by a variety of methods including lecture/tutorial format, seminars, workshop sessions and Personalized Systems of Instruction. Some courses relied to some extent on programmed learned material, so that a variety of teaching styles was evident. Assessment instruments used to monitor student performance included problem sets, quizzes, term examinations and essays. This *formative evaluation* was used to improve student performance and in addition the feedback was used to improve the quality of teaching.

For the purposes of the degree award the validating bodies insisted on adherence to a Marks and Standards document drawn up by the validating bodies after consultations with the College authorities. Such *summative evaluation* was based on five examination components viz. Physical Education, Education, Foundational Subject, Dissertation and Teaching Practice. Marks for dissertations were agreed by intern and extern examiners and Teaching Practice grades were also specifically subjected to external monitoring, a sample of students having been visited during the practice by the external examiners concerned. In each of the other three components students were required to present for a number of written comprehensive examinations, Physical Education (4) Education (3), Foundational Subject(2-3). The continuous assessment marks were subsumed in a Course Work element which contributed to the overall mark in each of the areas, Physical Education, Education and Foundational Subject Elective, according to an agreed formula. Course work in mathematics, for example, contributed a maximum of 25 per cent of the marks for mathematics. All elements of the programme including course work were externally monitored by the validating bodies and external examiners were involved in setting and marking all degree examinations. The degree examination for mathematics students graduating in 1978, for example, consisted of Physical Education (4 papers), Education (3 papers), Mathematics[1] (2½ papers), Dissertation and Teaching Practice. To date the validating body has been involved in degree examinations which occurred at the end of the programme only but the College is moving towards a position where there will be a Part 1 (after two years) and a Part 11 (at the end of the course) degree examination, each part externally monitored by the validating body.

---

1. Appendix E contains a full set of examination papers set in mathematics for 1978. Sample synoptic papers from previous years are also included.

In conclusion something should be said about the impact of the programme. Student achievement has been consistently high but not so high as not to require attention. This fact is borne out by degree examinations which have been externally monitored by the validating body and in every instance examinations and results have been confirmed. Those students who have found employment teaching mathematics in secondary schools, and there are several, have received favourable comment from the inspectorate, who send reports periodically to the College as feedback. As for the programme itself it has been received well by the validating body. The initial programme was validated by the National Council for Educational Awards without alteration. The first revision was submitted to University College Cork and it too was validated without alteration for the award of B.Ed of the National University. The report of the visiting committee which comprised Professor P.D. Barry (Mathematics), Professor P. Reagan (Computer Science), Professor A. Moran (Statistics) and Dr F. Holland (Mathematics) had the following points to make[125]:

> Of the course in Mathematics it can be said that
> (i) it is broad;
> (ii) techniques are covered, the manipulations being of moderate difficulty
> (iii) there is an emphasis on the understanding of concepts - this being very appropriate in a College of Education;
> (iv) There is little development of theory except in the easier sections;
> (v) Applications are included.
>
> The instruction is systematic and well organised. The level of the course corresponds to an approach in which students master the material they encounter rather than to a more ambitious inclusion of topics which stretch the good students and are beyond the range of weaker students.

Other expert opinion was sought while the programme was in the making and as it evolved. In all the programme and revisions have been examined independently by three university professors and one university education department and in each case the reaction was favourable. The impact is perhaps best described in the words of Professor S. Tobin, University College, Galway[1] ... "It is basically well-designed for its purpose and that it is good enough to be worth improving." These views represent opinion from one constituent college of the National University and an independent Irish university as well as one English University. Not wishing to detract from the importance of the above evaluations the words of a practising mathematics teacher in a second level school in Ireland, himself held in high esteem by his local Vocational Education Committee are perhaps more pertinent in the long run[2]:

> As an overall comment I would say that the entire course is exceptionally good. A student teacher, who we presume will complete the course and gain a reasonable pass in his final assessment, would undoubtedly be quite competent to teach in any area of Second Level Maths in this country. The teacher training end of things is in my view, far and away the best (as regards Maths) of any teacher-training in this country. Maybe in fact, it is the only course giving specific training in this area.

1. Source: Private Correspondence
2. Source: Private Correspondence

CHAPTER VII

PSI AT THOMOND COLLEGE OF EDUCATION - A PILOT STUDY

The projected needs of future mathematics teachers for Irish secondary schools were reflected in the Mathematics Programme which evolved at Thomond College. From the outset Computer Studies was an important part of the actual programme as it was implemented, and its inclusion mirrored its importance in the underlying programme philosophy - a philosophy dealt with in considerable detail in the previous Chapter (Ch. VI). Many important features - some novel in the Irish context - were incorporated into the Mathematics Programme and two new features advocated in the underlying philosophy have particular relevance to the subject matter of this chapter. In an attempt to prepare future mathematics teachers for *future* demands on them in mathematics education a course in Computer Studies was projected as an integral part of the overall programme. And an attempt to maximize the beneficial learning of students led to the acceptance of the principle of exposing students to different teaching styles in their own education as individuals and future teachers. A determination to see the programme through in an honest form despite the absence of ideal conditions for educational research renders the fusion of the new course and new teaching style partially explicable.

Add to these considerations, and others presented in the following pages, the conviction that educational research is as much the positive use of *actual* conditions as they present themselves to the researcher to investigate problems as investigations conducted under so-called ideal conditions. So long as the researcher describes the constraints and recognizes them as limitations and is careful not to make exaggerated and/or unsupported claims then the admissibility of what actually happens under existing conditions in education cannot be denied. An analysis of mistakes is as likely to be as valuable as a record of successes in educational research generally. Further, the positive desire to exploit one's position in education for research defeats the immobilizing tendency of succumbing to the posture of preparing for the day when ideal conditions materialize - a day that is unlikely ever to be realized in the Irish context. This study therefore circumscribed as it is by constraints and limitations is presented as work accomplished - a pilot study - in support of the main thesis.

The rationale presented above despite being fundamental in its importance is less than totally illuminating. Important questions remain unanswered - the reasons behind the choice of Computer Studies need further elaboration, and the considerations leading to the selection of the PSI format are less than adequately dealt with to date. Some time is devoted now to a more expansive treatment of these two important questions. The discussion of such questions must be viewed as an integral part of the research process, in this case the experiment in self-paced learning conducted at Thomond College.

1. Why PSI?

The teaching strategy adopted and subsequently implemented in the Computer Studies course at Thomond College of Education was the self-paced, mastery-oriented method of instruction known as the 'Keller Plan' or Personalized System of Instruction (PSI). The original formulation of this system can be found in Keller [126]. However, since then various interpretations, applications and evaluations have been reported in the literature mainly in the U.S. (Sherman [127]) and latterly in the U.K. (Elton, Boud and Nuttal [128], Boud et al [129], Romiszowski, Bajpai and Lewis [130], Stace [131]) and Ireland (Baker [132]). The characteristic features of PSI were retained in this experiment but the format was modified and adapted to suit local circumstances.

The initial decision to adopt the PSI format was influenced by several educational considerations relevant to the teacher-education context. Firstly, and perhaps most importantly from the author's view view-point was the conviction that future teachers should, in their own education, experience different teaching styles first-hand. Secondly, the mastery requirement and thereby the implied self-pacing had strong appeal since in the author's view the inevitable arbitrariness of the traditional 40 per cent pass standard and its questionable value as an index of attainment in tertiary education generally, undermined its role as a measure of attainment for future teachers. Teaching competency in one's chosen subject must demand among other things, a greater grasp than the traditional pass level, in our experience, invariably signifies. A certain mastery of content is required and *mastery is an undilutable concept*. How to define and then attain such mastery constituted a new problem, a problem which would be alleviated in some degree, it was hoped, after experience with PSI. Thirdly, the generally acknowledged future dependence of teachers on independent study after completion of their initial training was at the time of the experiment causing the author considerable concern. The absence of *specific preparation* in this respect in the education of future teachers represented a deficiency which could not be ignored. The avowed principle of requiring suitable standards in independent study is seldom matched in *practice* by a *structured approach* in this respect. The goal is generally considered accomplished if an 'appropriate' performance is recorded in the various courses. This state of affairs leaves much to chance and in view of the importance of independent study in the lives of teachers the vagaries of chance are unacceptable. Finally, dissatisfaction with the conventional approach to mathematics and physics teaching, an approach characterized by an appropriate mixture of lectures, tutorials, laboratories, problem sets and examinations, stimulated a desire to experiment with new teaching methods. Fortuitously, a search of the literature led to the discovery of Keller Plan or PSI, a relatively new instructional system which was enjoying considerable success in institutions of higher education especially in the U.S. It seemed a worthwhile project to investigate its potential in Ireland in relation to solving some of the difficulties already mentioned.

The self-study nature of PSI courses and the acknowledged benefits in this respect derived from such structured activity were particularly attractive. The mastery-oriented learning exemplified by the unit perfection requirement for advancement in PSI courses also had strong appeal. These advantages were confirmed in many individual research papers but reviews by Kulik et al [133], [134], Taveggia [135], Hursh [136] and Boud, Bridge and Willoughby [137] lent weight to the general consensus that PSI was indeed more effective than other methods. Specifically the literature confirmed the effectiveness of the PSI format as measured by student performance on course content examinations, a significant improvement over all other teaching methods in American colleges previously analysed by one of the authors [135]. With such credentials PSI can hardly be ignored by academics in colleges of education!

2. Why Computer Studies?

The choice of course was deliberate, Computer Studies being chosen for reasons related specifically to the discipline and its place in the education of teachers. But the role[1] of Computer Studies in the education of future mathematics teachers was accepted as particularly important by the author who was conscious of the need for, and development in computer education in Irish schools. The Computer Education Society[2] of Ireland (CESI), an association of secondary school teachers and other interested parties has since its inception in the early seventies carried the burden of generating interest and enthusiasm, and maintaining development in computer education in Irish schools. The society remains the single, most positive agent of change in this aspect of Irish education. Allegiance to the principles

---

1. This point and related matters are elaborated in Chapter VI, p.237

2. The Computer Education Society of Ireland is an outgrowth of the summer courses in computing for secondary teachers conducted by Professor A C Bajpai at University College, Galway, for several years spanning the early seventies. Professor Bajpai's pioneering efforts then are responsible for bringing Computer Education to Irish schools. The author was 'recruited' by the Professor at such a course.

of the society was a significant factor in the decision to choose the Computer Studies course for the experiment. The evident need for mastery of content and the apparent self-study basis for the achievement of mastery in this discipline also contributed to the decision to adapt the Computer Studies course to the PSI format. The PSI format was attractive for another reason. The desire to present a Computer Studies course consistent with a firmly held philosophy of computer education presupposed the availability of appropriate written materials. Some suitable material was already available in the form of the programmed text by Bajpai, Pakes, Clarke, Doubleday and Stevens [138], but other materials were developed by the author who generally contrived within the system to promote a course based on a particular philosophy of computer education. Another factor was also at work. The desire to promote computer education in Irish schools led to the conclusion that the availability of computer courses in the PSI style for in-service training would further this aim. The latter aim was an important aspect of the broader goal viz to bring in-service training to mathematics teachers in their homes or schools on a continuous structured basis throughout the year.

3. PSI Examined

Besides its obvious appeal in the circumstances the author conscious of his role in the teacher education context, felt obliged to examine possible objections to the use of PSI as a teaching method. First, however, it was necessary to characterize the system and thereby establish those features of the system which distinguish it from conventional methods of instruction. As Green [139] put it, Keller Plan is basically "an instructional system designed to exploit what has been found about learning from the perspective of "reinforcement theory"". The objective is to optimize learning by constructing a sequence of three-element cycles including *presentation, response and consequence.* This is accomplished in the Keller format whose fundamental tenets are listed as follows in Keller's [126] original paper published in 1968:

1. "The go-at-your-own pace feature, *which permits a student to move through the course at a speed commensurate with his ability and other demands upon his time".*

2. "The unit-perfection requirement for advance, *which lets the student go ahead to new material only after demonstrating mastery of that which preceded."*

3. "The use of lectures and demonstrations as vehicles of motivation, *rather than sources of critical information."*

4. "The *related* stress upon the written word *in teacher-student communication," and finally:*

5. "The use of proctors, *which permits repeated testing, immediate scoring, almost unavoidable tutoring, and and a marked enhancement of the personal-social aspect of the educational process."*

Kulik and Kulik [134], on the basis of the evidence available attribute the success of the plan to the fact that it involves small work-units, provides for immediate and specific feedback and requires mastery at every step. In the same paper Kulik and Kulik conclude that the system is superior to all other teaching methods as measured by its effectiveness in improving end-of-course performance retention, transfer and student attitudes. In their judgement "this is the most impressive record achieved by a teaching method in higher education." These important findings allied to the main conclusions of Kulik, Kulik and Carmichael [133] viz. that students usually prefer PSI over lecture method, and they usually learn more in the personalized mode as indicated by final examinations, constitute comprehensive supportive evidence for use of the system in any higher education environment including colleges of education.

Confidence in PSI is generated by the abundance of well-documented supporting evidence of success which abounds in the literature on PSI but such confidence must be tempered somewhat by considerations of another kind. There are some who have misgivings and while their arguments may not be supported by investigations of the kind demanded by reviewers nevertheless they must not be dismissed lightly especially when the evidence weighs so heavily on the side of PSI. Young [140] has raised important issues in his paper which is essential reading for anyone considering PSI as an alternative. His fundamental objection stems from his conviction that learning "requires an open-ended process of involvement between professor and students" and is not therefore a "patterned acquisition of information." The latter is equated with learning by PSI. His difficulty, therefore, is that the PSI format redefines the role of the teacher in an unacceptable way. The new role is unacceptable on two related counts namely the *teacher* decides and *in advance* what is to be learned by the students, and the teacher becomes, among other things, a tutor of tutors as opposed to a co-discoverer with his students. Hursh [136] draws attention to one of the major criticisms of PSI as an instructional system namely, the charge that PSI is unsuitable for courses demanding higher level objectives i.e. objectives aiming at analysis and synthesis. There is insufficient empirical data available on which to base firm conclusions; however, Hursh [136] insists that "Logically there appears to be no compelling reason to suspect that an appropriate adaptation could not serve such objectives well." While these issues merited consideration in the circumstances, the ramifications were not sufficiently off-putting to cause abandonment of the project since interest in PSI in this instance stemmed from its appeal as a new teaching style to be experienced and studied *as such* under actual working conditions in an effort to estimate its potential in the education of mathematics teachers for secondary schools in Ireland.

Objections on practical grounds relate to difficulties encountered during the planning and implementation stages. These are not inconsequential but instructions supplied in Keller and Sherman [141], which was to hand, seemed sufficiently comprehensive and intelligible to the novice. Because of the small numbers likely to be involved in the experiment considerations of cost were not a deterrent. The consensus view supported by Boud, Bridge and Willoughby [137] , seems to be that costs of self-paced courses are the same as a traditional course when numbers are small (1-10 or 12 students). Other practical considerations such as the availability of time for writing units, the reorganization of time-tables and allocation of physical resources were problematic but after some academic manoeuvres internally within the college it transpired that the way was clear to conduct the trial.

4. Computer Studies - the Course Syllabus

The PSI format suitably adapted and modified was employed as an appropriate means of implementing an important element of the Mathematics Programme viz the Computer Studies syllabus. The course syllabus had been devised by the author and accepted by the validating body - University College, Cork for the National University of Ireland - without modification. It was included as part of the Mathematics Programme which comprised a significant element in the Thomond College of Education course submission to University College, Cork in 1977 for recognition as degree status. The course was duly recognised as such earning the award of a classified B.Ed. degree. A similar syllabus figured in a previous degree submission to the National Council for Educational Awards and it too was accepted. The relevant passages from the Thomond College Submission [142] to University College, Cork are reproduced below:

> This is decidedly a computer appreciation course and is in no sense directed towards the training of computer programmers. However, this course is built on the premise that appreciation is facilitated by doing and hence the inclusion of programming as a topic and activity. The computer is treated as an information processing system.
>
> The objectives of the course are:
>
> - To examine the function and capabilities of the various elements which constitute a typical computer system
> - To introduce flow charts and simple programming
> - To promote in the student the acquisition of a disciplined logical approach to problem solving.

The course syllabus is as follows:

<u>Information Processing</u>	:	Organisation and presentation of information, algorithm, problem definition, flow charts.
<u>Binary Arithmetic</u>	:	Conversion from base 10 to binary and vice-versa, Alphanumeric characters, numbers and instructions in binary form.
<u>Concept of a Program</u>	:	Analysis of flow charts, source program, object program, programming language.
<u>Structure & Organisation</u>	:	Memory, arithmetic unit, control, I/O, storage of program, bits, bytes, words.
<u>Hardware</u>	:	I/O devices, immediate access store, backing store.
<u>Software</u>	:	Assemblers/Compilers, operating systems, program library.
<u>Programming</u>	:	Writing simple programs in a high level language, either FORTRAN or BASIC.
<u>Computer Applications</u>	:	Scientific, business, other applications, computer industry, computer developments.

This course may be seen to contribute to the realization of the overall (Mathematics Programme) objectives in the following ways:

- It is functional in relation to the school environment
- It has great applications value both within Mathematics and outside it.
- It equips students to come to grips with one of the most significant recent technological developments as it relates to society

It is obvious that a syllabus devised in such circumstances reflected a personal approach to the projected needs of future mathematics teachers in Ireland and as such stands on its merits. But more significantly in the Irish context it represents the only time, not counting the author's other submissions, that Computer Studies has been approved by degree validating bodies as an important element in the initial education of future mathematics teachers. *In fact the Mathematics Programme at Thomond College of Education represents the only incidence in Irish education of a programme specially designed and conducted with the special needs of future mathematics teachers for secondary schools in mind.* A special significance therefore attaches to the programme by virtue of its uniqueness in Irish education.

5. Computer Studies - the PSI Course

The Computer Studies course as it evolved in the PSI format was shaped by many factors some of them identifiable in the milieu as being formative. Adherence to the PSI format imposed certain constraints. The demands of organizing the subject matter into units, devising the unit format, and actually writing the subject content of the units were pressing and only relieved by making a series of operational decisions. Personal prejudices inextricably tied, as they are, to professional preferences played a large part here. Inevitably the selection of subject matter and its treatment and presentation in unit form was shaped by past experience professional and otherwise. One is never completely detached from his experiences as a student and perhaps teacher on other computer courses, nor can one discount the influence of a personal educational philosophy however embryonic or rudimentary in its contemporaneous stage of evolution. Surprisingly, a large number of decisions were made *consciously* i.e. one was definitely aware of making a series of decisions, *many more* decisions in fact than one would have attributed to the demands of running a traditional course. It was inevitable therefore in the circumstances that each unit would bear a personal stamp in terms of content, treatment, presentation and organization. The adaptations and modifications represent an important consideration in the development of a PSI course and therefore warrant a closer examination.

The unit format ultimately adopted after much consideration and many abortive writing attempts was so devised as to allow inclusion of known aspects of unit design as these were gleaned from the literature. Further the design had to be elastic enough to accommodate new idiosyncratic features. These dual specifications shaped the unit format which resulted (Fig.7.1). Each unit was prefaced by an introduction which was used to highlight the importance of the unit content, place it in perspective and to indicate probable areas of difficulty. The unit objectives stated in behavioural terms followed the introduction and preceded the section on procedure. The writing of appropriate objectives demanded a precision in thought and language which was acquired only after disciplined application to the task and detailed analysis of the unit subject content. A realistic balance

1. INTRODUCTION

2. OBJECTIVES

3. PROCEDURE

4. UNIT SUBJECT CONTENT

5. STUDY QUESTIONS

   .1 LIST OF IMPORTANT CONCEPTS
   .2 LIST OF TECHNICAL TERMS
   *.3 PRACTICE QUESTIONS
   *.4 SELF-PROGRESS TEST
   *.5 CASE STUDY

6. BIBLIOGRAPHY

*7. DIAGRAMS, CHARTS, TABLES

8. MASTERY TESTS

   .1 MASTERY TEST 1
   .2 TEST KEY
   .3 MASTERY TEST 2
   .4 TEST KEY
   .5 MASTERY TEST 3

*These items do not necessarily accompany every unit.

UNIT FORMAT

FIGURE 7.1

between the number of objectives listed with each unit and later assessed in the mastery test for that unit effectively circumscribed the amount of material which could be included in any single unit. Material requiring more than ten objectives could not be adequately assessed in a short ten-item test which was the assessment instrument selected for the purpose. A suggested or recommended procedure for attaining the objectives was detailed in the procedure section. This included references to the programmed text and any special instructions needed. Those units which by the nature of the objectives and the non-availability of appropriate material demanded the development of the subject content ab initio by the author included after the procedure section a section entitled 'Unit subject content' which set out all the study material in the desired form. Not every unit required such an effort and those without the unit subject content section passed immediately to the study questions. This section is characterized by a list of practice questions and/or a self-progress test or sometimes a case study. It always included a list of important concepts and technical terms encountered in the unit and summarized in this way as a means of reviewing the unit material. The inclusion of these lists apart from their value as a means of review was prompted by a concern to minimize the effects of the subject 'jargon' on the learning process of the students, an important concern of the mathematics educator who has to cope with the problems of a subject which uses colloquial terms in a technical sense. The source of all materials used in the unit was acknowledged in the bibliography a section inspired more by the desire to promote good independent study habits, a reason for introducing PSI in the first place, than by the professional requirements of intellectual and academic honesty. Diagrams, charts and illustrative material requiring full page presentation were appended in serial order after the bibliography to be followed in turn by the mastery tests for the units. Units were usually assessed by short ten-item tests. However, different mastery criteria were specified when necessary and appropriate. For example later units required the writing and successful processing of a complete computer program including the flowchart and coding sheet. Test keys were devised when the tests were constructed and in retrospect *this proved to be a very important step as it served to reduce confusion in the marking of sessions.* Obviously the tests and keys were kept securely apart from the other components of the unit which were for distribution to students. The essential features of each unit and many of the others are displayed in Unit 3 (Appendix F).

The actual material for the units as it developed was shaped more by underlying philosophy than anything else. It is important to mention in this respect that the Mathematics Programme included Computer Studies as an element not only because it was important for future mathematics teachers but also because computers play a vital role in everyday living, an aspect which impinges upon every citizen. Consequently it is of the utmost importance that the educated layman comprehend the role of the computer in modern society; its strengths, weaknesses and limitations. This fact accepted, the successful conclusion of such an undertaking presupposes the existence of teachers trained with this in mind. Not all teachers in training in Ireland were accessible to the author, however, those who were experienced such preparation in their initial training - a preparation which served a dual purpose in this instance firstly, as an appropriate study for further mathematics teachers, and secondly, as part of their general education as teachers.

A predisposition towards problem solving as defined in a wide psychological way resulted in a treatment of the computer as an information processing system. The basis of the approach is given by Jackson [94] who defines problems generally as arising from thwarted goal-directed activity which may be denoted symbolically:

$$P = 0 + 0$$

i.e. problem equals obstacle plus objective. This approach in turn presented the opportunity of introducing a problem solving heuristic based on Polya's [143] which is generally available in the literature. The various stages in problem solving were interpreted in the computer context [144] and used to further the aims of the course. Appreciation was promoted by doing and in order to facilitate meaningful activity in a computer environment a considerable segment of the course was devoted to developing a programming language (FORTRAN) and programming techniques including flow-charting. This approach was aimed ultimately at allowing the student as user (problem solver) to arrive at a position where he would possess sufficient knowledge and skill to exploit simple applications packages at any local computer centre. Later units in the Computer Studies course dealt specifically with this aspect, an aspect towards which all the other work contributed in the long run.

It was no accident either that the Mathematics Programme promoted as an explicit aim the development of a problem solving capability in the student of mathematics even in a teacher education environment. *This aim was a fundamental tenet of the underlying programme philosophy.* The computer obviously has a vital role to play in any such enterprise nowadays. Thus a dual purpose was served by Computer Studies. It contributed in its own unique way to the attainment of the objectives of the overall programme and to the other aim of promoting the process of creating an attitude in a future generation which will allow people to appreciate more fully and to their advantage, the role of the computer in their lives.

6. Implementing PSI at Thomond College

Many problems were anticipated but as invariably happens in empirical studies some of the most formidable problems were only recognized as such during the actual experiment. This occasion proved no different than others. While the scheduling, organizational and managerial duties seemed to be more formidable initially, the writing of course units proved the most daunting task. In retrospect it is clear that the fact that much material had to be developed ab initio in accordance with a predetermined course philosophy and objectives contributed significantly to the difficulty of the undertaking. As a first step a format (Fig.7.1) the result of experimentation and consideration, was adopted which would serve as a framework for each unit. Then ten individual units were developed within this framework. The actual time spent in writing units varied greatly with individual units. The task was facilitated and greatly enhanced by keying units to a programmed text in computer programming. Some units, nevertheless, required considerable working and reworking before an acceptable typescript emerged. This was especially true of those units which were developed to add one's special flavour to the overall course. A subjective analysis of time spent on the actual writing of units showed that writing time per unit varied widely, from three hours for the most straightforward to twelve hours for others, the modal time being six hours. However this type of analysis of writing time can be misleading since it is divorced from important and time-consuming aspects of the writing process e.g. the incubation period - that time spent thinking about the material, searching for and checking new material, developing appropriate objectives and the like. Experience has shown that a week per unit is a typical time span for the process from incubation to the final typescript.

During the writing process considerable time was devoted to each of two tasks - writing behavioural objectives and constructing mastery tests for each unit. These tasks were formidable in the absence of appropriate subject-related guidelines. There is a considerable literature dealing with writing behavioural objectives but no references could be located at the time which were discipline-related to Computer Studies. Despite this Plowman [145] proved a valuable aid in this respect and behavioural objectives for each unit were duly developed. These objectives eased the task of constructing mastery tests. Three different ten-item tests were devised for each unit. The tests included two original tests and a third derived from the other two. In some instances it was necessary to define different mastery criteria as for example in Unit 7 which demanded the successful processing of two short computer programs, and Units 8 and 9 which required a written test as well as evidence of successful computer runs. *All* questions on tests had to be answered correctly and the only concession here was the opportunity to correct a maximum of two questions orally at the marking session.

The PSI course in Computer Studies was first run at Thomond College during second term in the school year 1975/76, and again in the same term in the following year. The course was scheduled for second term so that self-pacing could be maintained by extension into third term if procrastination became a major problem. The course was required for students who opted for mathematics as their second teaching area[1]. On each occasion Computer Studies was available only PSI-style so that students had no choice of format. In the first year the course was taken by the final year mathematics class consisting of seven students, four male and three female. The four male students in the corresponding class in the following year comprised the experimental group. Two one and one half hour periods per week were timetabled in a designated classroom for the ten week term. During this time students were permitted to use the classroom as a study hall and to take mastery tests. This classroom became the nerve-centre of the course. It served as study hall, test centre and distribution point. Course materials were distributed there and announcements made and posted there. The availability of the classroom was extended for the second group upon

1. All students in the four-year degree programme are required to become competent teachers in *two* areas of the secondary school curriculum, namely, Physical Education and one other area chosen from a range of options including Mathematics.

request and eventually it was available as a study hall at all times during the day. No lectures were offered but a short conducted visit to the Computer Centre was scheduled and took place early in the course. All students were expected to attend and did so. No final examination was scheduled and students were guaranteed an A-grade convertible to an agreed percentage mark upon successful completion of all course units. The grading options were elaborated for the second group and included the specification of a minimum number of units for pass, C, B and A grades. Their currency in percentage points was agreed with the class. In the absence of a graduate class or peer group the author acted as proctor.

At the first meeting with students, on each occasion an explanatory hand-out was distributed. It contained a brief description of PSI and a statement of course policy and requirements. The mechanics of the course were briefly explained by the lecturer and students were given Unit 1 and left to get on with the work. On the occasion of the first meeting with the second group in addition to the introductory material presented in the previous year and now suitably updated the students received a copy of the course syllabus and a brief description of each unit. This was in response to a perceived difficulty with the first group which was highlighted during the proctor-student encounters. It was felt that an overview of the course presented in this way at the outset and continuously available thereafter would help towards the development in the student of an overall course perspective which would counteract the tedium of working frame after frame of programmed material and improve his motivation.

Student reaction on each of these first sessions can fairly be described as one of disbelief. Some protestations of disbelief in their state of new-found freedom were voiced; however, students were reassured by the lecturer's affirmation of commitment to the course ideals.

7. Student Performance

The small number of students in each group and the fact that the lecturer carried out the proctoring duties promoted a liaison which allowed close monitoring of individual student's performance. This situation was greatly enhanced by the relative maturity of the students, their enthusiasm and their general willingness to discuss the course. The students welcomed the prospect of such a course from the outset and were visibly enthusiastic. Each student's progress was recorded on a progress sheet, and students were kept aware of each other's progress. Evaluation of student performance is based on these progress sheets, recollection of important matters in the proctoring situation and informal conversations with students as well as some recorded notes.

The usual problems of student procrastination were not evident. The early units were completed promptly usually within a week, and a week per unit seems to have been adopted by everyone involved as an informal yardstick for measuring his personal progress. Early success was not accidental. Students were introduced to the course by means of early units which were easier and shorter than later units in the interests of developing student confidence. Mastery tests were attempted usually after a period of up to one week and invariably passed at the first attempt - although many occasions saw the use of the oral-correction option in the proctor-student encounter. Members of the first group complained mildly about the difficulty of units after the fourth unit. Further probing revealed the nature of the difficulty. These later units relied heavily on the programmed text and the *number* of short frames seemed to be the cause of the problem. Each admitted an unwillingness to get on with the work due to the number of frames but found no real difficulty in doing it. Action was taken on foot of this difficulty to alleviate similar problems with the next group. Progress generally in each year was good until the seventh unit, with no one at any time more than one unit behind the leader. In the first trial technical and administrative problems beyond the lecturer's control disrupted the course at this point. A period of six weeks elapsed during which time computer services were only intermittently available and never satisfactory. This brought students very close to final examination time and efforts to complete the other units had to be abandoned in the interest of the students in the wider college context. Each student agreed and subsequently received a C-grade upon completion of unit seven. Students displayed considerable annoyance at being unable to proceed further and expressed a desire to receive the remaining units in order to have a complete written record of the entire course for future reference. This was done and the practice was repeated for the second group. Three members of the second group completed unit 8 with the fourth member proceeding to complete the entire course. Members of the latter group were pleased to accept the grades they had earned.

8. Evaluation

The students reacted very favourably to the course. After initial anxiety they were quite happy to work on their own at their own pace. The designated classroom became less important as a study hall for the first group as the course progressed, the students preferring to work elsewhere and report to the classroom for mastery tests. Quite the reverse was the case with the second group of students who sought to have the classroom available at all times on a continuous basis even when the proctor was not present. Generally students were surprised that no efforts were made to dictate the pace. They really did not believe at first that they could proceed at their own pace despite the lecturer's protestations to that effect. Students came forward to express their views and appeared quite convinced that they were doing better compared with other courses. They enjoyed the experience and were willing to spend more time on this course than others. The consensus view for each group was that they were actually spending more time on the PSI course compared with others but no complaints were aired. The students wondered why this was the only PSI course in the college and some considered themselves deprived because it was not introduced earlier.

From a teacher's vantage point the quality of the teaching and learning experience was good and a decided improvement over others tried in Computer Studies. Student achievement in both years was higher than in 1975 when the same course was run in a traditional format. In that year less material was covered in a comparable time period. Evidence in the form of greater facility and comprehension as well as work output was abundant especially during the personal interaction at the proctoring sessions. The added bonus of an organized and structured provision for independent study enhanced the whole process. The efforts in planning and writing, recording and administration, proctoring and managing, were amply rewarded in each trial run, and despite the curtailment experienced in the first year due to unforeseen difficulties.

These experiences generally, replicated those of other PSI users as reported in the literature. In an effort to pursue the objectives in introducing PSI in a teacher education context an appropriate evaluative instrument was sought. The small number of students in each of the experimental groups and the concomitant implications of this circumstance for reliability of information obtained compounded the problem of finding an appropriate instrument for evaluation. In view of these constraints the Semantic Differential was selected. It was chosen on the basis of (1) its appropriateness for obtaining information about the objectives (2) its potential for obtaining valid information even from individual cases (3) its relative ease of administration, analysis and interpretation. It has been reliably tested in cross-cultural situations and the form used was recently validated by a colleague[1] in the Irish context.

The Semantic Differential is a method for measuring the meanings attributed to concepts by individuals or groups. The meanings are

---

1. The form of the Semantic Differential used was validated for use in Ireland by Mr T V Power as part of his research for an M.Ed. degree, who graciously consented to its use in this experiment.

defined by reference to known dimensions in a 1-,2- or 3-dimensional semantic space. The space axes or dimensions denoted Evaluation (E), Potency (P), Activity (A) have been determined previously by empirical means using Factor Analysis. A single axis or dimension may be selected as the focus of research and a 1-dimensional space constructed with reference to the chosen axis. In such cases the Evaluative or E-dimension is usually chosen because of its significance. The method was developed by Osgood and described in Osgood, Suci and Tannenbaum [146]. There is a useful discussion of it in Kerlinger [147].

The actual instrument consists of a number of scales each of which is a bipolar adjective pair. The adjective pairs are chosen for the specific purpose at hand. The scales are usually seven-point scales although others have been used. In this case the E-dimension was considered most important and an attempt was made to construct a 1-dimensional semantic space for each student. Six evaluative seven-point scales (Figures 7.2-7.3) were embedded in a set of twenty scales and three separate questions were asked concerning PSI. Each question was presented on a separate sheet containing the same set of twenty scales. Response bias tendencies were combatted by randomizing the serial presentation of scales on each sheet and effecting random reversals of the bipolar adjective pairs. The results are summarized in the Tables(7.1-7.3)

Interpretation of results is dependent upon familarity with certain key notions. The use of the term 'concept' is very general and just

CONCEPTS

A: You have recently experienced a course designed on the Keller Plan Model. Consider the experience focussing on the model as a basis for structuring teaching at the third level.

B: Consider the Keller Plan Model in the context of your preparation as a teacher in this College.

C: Consider your recent experience of the Keller Plan and concentrate on the assessment feature of the model.

SCALES (EVALUATION)

WORTHWHILE	-	WORTHLESS
SUCCESSFUL	-	UNSUCCESSFUL
GOOD	-	BAD
RELEVANT	-	IRRELEVANT
IMPORTANT	-	UNIMPORTANT
INTERESTING	-	BORING

CONCEPTS AND SCALES

FIGURE 7.2

Very | Slightly | Slightly | Very

WORTHWHILE : X : : : : : : : WORTHLESS

7 6 5 4 3 2 1

Quite | Neutral | Quite

Each scale may be crossed in only one position by the subject

SCALE INTERPRETATION

FIGURE 7.3

about anything may function as a concept for the purposes of the Semantic Differential. The meaning of a concept to an individual is the factor score of the concept i.e. the mean of the scale ratings for the given factor. The meaning of a concept to a group is the average factor score of the concept over the individuals in the group. The difference between the meanings held by the same group of any two concepts is measured by D, the distance between the corresponding points in the semantic space. If these distances are all zero then there is no difference in meanings for the group under consideration. The analysis and interpretation of results is centred around the above ideas and because of this, little if any, statistical analysis is necessary. Various statistical tests of significance may be used but care must be exercised as to type and interpretation since questions of independence of trials and normality of data arise. This study did not warrant such detailed statistical analysis.

The data for each group shows that individually each student's evaluation was more than slightly in favour of the Keller Plan model as a means of structuring third level education. Some were very much in favour. As regards Keller Plan in their own preparation as teachers. the experience was quite or very much valued by all students in each group. A similar situation obtains in relation to the assessment feature of the model. It is significant to note that no factor scores were less than the neutral indicator 4. As a group the students, in each year, showed a high average factor score suggesting quite a favourable attitude to each of the concepts. Since each possible

TABLE 7.1

MEANING OF CONCEPTS TO INDIVIDUAL SUBJECTS

	SUBJECTS	FACTOR SCORE A	B	C
GROUP 1	1	4.50	5.33	4.83
	2	6.50	6.67	6.33
	3	6.67	6.33	6.83
	4	5.67	6.17	6.17
	5	6.17	6.50	6.50
	6	5.17	5.33	5.83
	7	5.83	6.33	6.33
GROUP 2	1	6.17	6.00	6.50
	2	6.17	6.33	5.67
	3	6.00	6.17	6.50
	4	5.67	6.00	6.00

The factor score is the meaning of the concept for the individual. The neutral scale point is 4. Factor scores greater than 4 may be interpreted as favourable.

TABLE 7.2

MEANING OF CONCEPTS FOR GROUP

	AVERAGE FACTOR SCORE		
GROUP	A	B	C
1	5.79	6.09	6.12
2	6.00	6.12	6.17

The average factor score is the meaning of the concept for the group. Average scores greater than 4 may be interpreted as favourable.

TABLE 7.3

DIFFERENCE IN MEANING BETWEEN CONCEPTS FOR GROUP

	D (DISTANCE)		
	D_{AB}	D_{AC}	D_{BC}
GROUP 1	0.83	0.33	0.50
	0.17	0.17	0.34
	0.51	0.16	0.50
	0.50	0.50	0.00
	0.33	0.33	0.00
	0.16	0.66	0.50
	0.50	0.50	0.00
GROUP 2	0.17	0.37	0.50
	0.16	0.50	0.66
	0.17	0.50	0.33
	0.33	0.33	0.00

A column of all zero entries indicates no difference in group meaning for given concepts.

pairing of the concepts does not yield a column of zeros it is reasonable to assume that the students as a group ascribed different meanings to the different concepts. Taken together and acknowledging the limitations of the study especially the small number of concepts and subjects, one can cautiously infer that each experimental group both as individuals and as a group displayed a favourable attitude towards PSI in general and also towards its use in teacher education.

9. Summary

The overall objectives were more or less achieved. The conduct of such a course places students in a self-study situation and success depends largely on developing those specific skills related to independent study especially learning from a variety of written sources. Students were afforded the opportunity to experience a new teaching style and criticize it in relation to their own learning. The mastery criterion remains the most problematic in relation to the original objectives. That the students learn more and in a better fashion is no doubt true and therefore the problem of the 40 per cent pass standard is alleviated in relation to this specific course. However, some fundamental difficulties remain, for example, (1) the meaning of mastery in the PSI context, (2) the question of validation of mastery tests and (3) the interpretation of mastery units completed, say 80 per cent of the course, and how this compares with 40 per cent pass in a traditional course.

At the practitioner level, the PSI format has much to recommend it to teachers. The author was particularly impressed by the robustness and flexibility of the course structure under PSI. Despite obstacles, for example, which caused the course to end prematurely in the first year the course objectives for the most part were met. The writing format proved surprisingly flexible and little effort was required to work in useful teaching techniques. Revision was encouraged by the use of summaries of important concepts, lists of technical terms, study questions and self-progress tests. A case study was easily incorporated into a unit as the most appropriate way of presenting the material. Many other possibilities exist which are in no way prohibited by the PSI format and philosophy. PSI therefore, at the very least merits an important place in the repertory of teaching styles used in institutions of higher education but especially in colleges of education.

It would be pretentious in the circumstances to do more than relate experiences and make observations. The limitations of the study are clearly evident and acknowledged by the author who prefers to treat the exercise as a pilot study. However this attitude must not be interpreted as condescension on the part of the author. It is rather, in line with the philosophy that it is more important and positive to experiment under existing conditions than to wait for 'ideal' conditions which rarely if ever materialize. It was no accident that the experimental groups were small. Each group represents the entire input into the Irish secondary school system of mathematics teachers who have been trained *ab initio* in an Irish College of Education to teach mathematics. It is unlikely that this input into the system will change substantially in the near future. In that context little else could have been done, but nevertheless the exercise has been constructive and obviously useful. The direction of future research in this area in Ireland has been established. After incorporating revisions into the present scheme and further experiment in the *small* featuring the use of audio cassette and video components the system will be ready for testing in the *small* on a group of 15-20 local mathematics teachers as an in-service course. These steps are seen as a necessary prelude to its extension to a wider national audience as an in-service course reaching teachers in their homes throughout the year.

Author's Note

[A paper jointly with A C Bajpai, based on this chapter, entitled "Experiences with a self-paced computer studies course in the education of mathematics teachers for secondary schools in Ireland" has been accepted for publication in *Programmed Learning and Educational Technology* and will appear in April 1979.]

CHAPTER VIII

A CASE FOR A NEW RATIONALE FOR THE EDUCATION OF MATHEMATICS TEACHERS IN IRELAND

1. Change and the need for adaptability in teachers

A most striking feature of modern society is the rate at which it changes [148]. Teachers in training, therefore, must somehow be provided with the wherewithal to discharge their responsibilities as teachers in a *changed* and *changing* society and school situation. This is a new and vital challenge for teacher education institutions. There have been many responses to the challenge but most, if not all, in recent years can be characterized by their attention to the *processes* of education. No one pretends now for example, that it is adequate to train teachers of mathematics by drilling them in various aspects of the subject. Few eschew *pedagogical* training even for graduates in mathematics. The future teachers of mathematics must learn to think mathematically, develop considerable 'know-how' in mathematics, be conversant with its history and appreciate its significance *and* be pedagogically informed in that subject. They must do this not only to be better prepared subject-wise, not only to be pedagogically adequate but so that they can *remain* professionally competent teachers of mathematics *throughout* their working lives. In a word, future mathematics teachers for Irish secondary schools must be *adaptable*. If their training programme achieves anything less it has failed to meet the most important challenge of the day in teacher education in Ireland.

The present and future requirements of secondary school mathematics teachers demands an ability to adapt one's outlook and practice to suit new situations. This is no more and no *less* than is demanded of all professionals irrespective of profession. Framed in this way, the problem for teacher educators is less forbidding since one can look to exemplars of education designed to develop adaptability in students. Bondi[149] has said that:

> The prototype of the school and university subject intended for adaptability, particularly between 1875 and 1960, was the classics. Why did anybody ever think that the classics would make people adaptable and good for almost any occupation they might enter later?

The inference here is that *extrapolation* occurred on the basis of a special kind of prior education and students were deemed suitable for *different occupations* on that basis. By analogy then, the author submits that the classics be accepted as the prototype of the subject best suited to cultivate adaptability in *mathematics* and use it, assuming *interpolation* is valid, as an exemplar to promote adaptability in intending mathematics teachers. The analogy can be carried further. If, as Bondi [149] has said, the way to make mathematics graduates more adaptable i.e. suitable for occupations other than mathematician is to "concentrate on mathematics as a cultural subject" then the way to make intending teachers of mathematics more adaptable in their role as mathematics teachers is to adopt a *cultural approach* to mathematics in their *initial training*. Interpreted this means that mathematics must have a legitimate place and important standing in the *personal education* of future mathematics teachers. The implication is that mathematics in a real sense must contribute to their formation as persons in a society bearing a certain culture, *and* mathematics as a significant feature of that culture bears on their education. No teacher of mathematics is worthy of the name who is not educated *and* educated in such a manner that mathematics makes a significant contribution to that education. However, teachers of mathematics are by definition *professional teachers;* they need not be *professional mathematicians.* Relieved of the burden of preparing professional mathematicians, the Colleges of Education and responsible agencies in Ireland must accept responsibility for preparing *teachers* of mathematics. In a changed and changing society the *adaptability* of the teacher of mathematics will be at a premium.

2. Adaptability and Subject-preparedness

It seems an obvious fact that teachers of secondary school mathematics are *subject* teachers i.e. they teach *mathematics.* Perhaps because of its obviousness this fact does not gain the attention it deserves and consequently its implications are not seriously considered. If the adaptability of the future teachers of mathematics in secondary schools is a priority, and the contention here is that it is, then that adaptability is directly related to the teachers' command of mathematics in the first instance. The challenge for teachers is to deal with mathematics *today* and in the *future* as a vital part of the education of *all* young people [150]. Mathematics is central to the education of all children because [151](p.1):

> First, a knowledge of mathematics is an essential requirement for everyday life in a modern society; mathematics is the servant not only of the sciences but also of industry and commerce. Mathematically educated manpower is essential to the well-being of society. Secondly, mathematics can in itself be a fascinating study for pupils, both as a means by which they may better their understanding of their environment, and as a way in which their powers of problem-solving, reasoning and conceptualisation may develop and they may gain access to new areas of thinking.

If mathematics teachers are to teach accordingly now and in the future then the author believes that they must be prepared *now* to do so. Their future adaptability will depend crucially on their initial preparation in mathematics and the continuing professional support they receive. It goes without saying that in the absence of some form of adequate continuing support - a deficiency which exists in Ireland - then the initial preparation of mathematics teachers for Irish secondary schools assumes even greater significance. The problem reduces to devising the best means *now* for educating mathematics teachers of *tomorrow*. The only reliable way to do this is to act on present knowledge. Mathematics as it is today *is* the only preparation for mathematics in the future. Therefore, mathematics as it is today must become the vehicle for adaptability in the Irish mathematics teachers of tomorrow. Teaching teachers of mathematics to be adaptable so that they can meet new challenges in mathematical education ultimately depends on their *subject-preparedness* i.e. their preparation in mathematics. The author believes that the only way to ensure that secondary school mathematics teachers in Ireland do not become redundant mathematically is to provide an adequate basis in mathematics for their own future development and *intrinsic* motivation for such development. The best way to accomplish this objective is to allow teachers to experience mathematics as being *cultural* in the first instance i.e. adopt a cultural approach to mathematics in the initial preparation of mathematics teachers.

3. Approaching mathematics as a *subject*

The central concern of this chapter is the ab initio training programme for teachers of secondary school mathematics i.e. a third level curriculum in *mathematical education*. Having said that and without prejudicing the claims of other areas of the curriculum to importance, nevertheless it must be stressed that for teachers of secondary school mathematics the primary consideration must be *subject competence*. Here the words of Long [107] et al reporting on a conference on Research in Mathematics Education held under the auspices of Cornell University Center for Research in Education have particular significance:

> It was felt that one of the most important qualifications for work in Mathematics Education is a high level of proficiency and ability in mathematics considerably in advance of the educational level of the mathematics on which the researcher is working.

These sentiments are equally applicable if 'teacher' is substituted for 'researcher'. There can be no effective teaching of mathematics in secondary schools, Irish or otherwise, if teachers do not have an adequate command of mathematics. And for that reason mathematics must be taken as the *starting point*. The focus of this study, therefore, is narrowed to include only mathematics per se on the assumption that an adequate command of mathematics is an essential prerequisite for teachers of mathematics but not the only one.

Mathematics is a corpus of knowledge, a field of study and a subject to be studied. Learning mathematics as a subject is more than the mere acquisition of facts, and teaching mathematics is much more than is implied by the phrase 'getting mathematics across'. Teaching mathematics as a subject demands a more penetrating approach. The student-teacher's attention must be focussed on the fundamental principles and ideas as a means of deepening his understanding of mathematics. The premise here is that this understanding demands mastery of the *structure* of the subject. The mathematics curriculum for the training of secondary school mathematics teachers, therefore, "should be determined by the most fundamental understanding that can be achieved by the underlying principles that give structure to that subject" [152] (p.31).

What is advocated here is essentially a modified Brunerian conception of subject as a structure of knowledge and inquiry. Bruner [152](p.20) has said that:

> Mastery of the fundamental ideas of a field involves not only grasping of general principles, but also the development of an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own.

For Bruner then a subject is primarily a way of knowing, a means of dealing with the world and making it intelligible. He has suggested that "the human, species-typical way in which we increase our powers comes through converting external bodies of knowledge embodied in the culture into generative rules for thinking about the world and about ourselves" [153] (p.131). He makes four general claims for the efficacy of the structural approach to mastery of subjects or bodies of knowledge such as mathematics: (1) understanding of fundamental structure makes a subject more comprehensible; (2) a grasp of principles is insurance against memory loss since an understanding of structure facilitates the reconstruction of details; (3) it facilitates transfer of learning; (4) it narrows the gap between elementary and advanced knowledge of a subject [152]. One can hardly deny the value of these aims for a future teacher of mathematics but in a climate where adaptability of mathematics teachers is at a premium the claim that a structural approach to mathematics will facilitate transfer of learning is most significant. In the author's opinion, it is only in this sense that learning mathematics *now* is in any way a preparation for the *future*.

Bruner sees subjects "as 'structures of knowledge' comprising concepts and theories, methods of research and enquiry, and the tests for establishing truth" [154]. By so doing he highlights the structural features at the expense of the historico-cultural dimension of subjects. That is to say that structure dominates as the generative feature of curriculum. The logical analyses implicit in the structural approach to the teaching of subjects leaves out a lot that is desirable in an educational setting and particularly in the education of future teachers [154]. Mathematics for example is a human symbolic system embedded in a historical-cultural context, has a pedagogy and institutional setting and is therefore socially significant by virtue of these aspects as well as its applications and uses in society. The modified view proposed here by the author is that

mathematics be treated as a discipline by concentrating on its structural elements *and* as a subject set in a historico-cultural context. In this way the structure of mathematics may be seen as cultural in the first instance since it is a characteristic way of knowing mathematics, itself a constituent element of the culture. Adopting a structural approach to mathematics becomes synonymous with a cultural approach to mathematics and consequently *culture* as well as *structure* becomes a generative feature of the mathematics curriculum.

4. On the Congruence of Structure and Mathematical Structure

The question of the relationship between Bruner's conception of structure and mathematical structure assumes great significance in the context of the education of future mathematics teachers. The ability of the mathematics teacher to respond to new challenges is critically dependent upon the potential of his mathematics education for transfer of training i.e. non-specific transfer or "transfer of principles and attitudes" [152](p.17). If teaching mathematical structure is the same as Bruner's structural approach to mathematics then there are grounds for believing that the potential of present learning in mathematics for future educational needs has been maximized, *assuming of course that the actual teaching is effective.* And for teachers of mathematics in secondary schools such considerations are of the utmost importance.

From a pedagogical point of view mathematical structure is a difficult notion to unravel. The term is ordinarily used by mathematicians in two senses, perhaps best distinguished by the use of singular and plural forms of structure i.e. mathematical *structure* and mathematical *structures*. While the two ideas are closely related it is nevertheless worth distinguishing between them for the insight one gains into the development of mathematics and for the purposes of curriculum building. Mathematics as a domain of knowledge exhibits a certain structure. The edifice of mathematics can be stripped to display its organizational structure i.e. it can be seen to be organized around certain fundamental principles and concepts. And to learn the structure of mathematics is to learn how the structural components combine to give mathematics. Since Cantor introduced his set theoretic ideas in the nineteenth century the potential for organizing *all* of known mathematics around a minimal number ofconcepts and principles has existed. This potential has been realized in the twentieth century on the basis of sets and the axiomatic method. So in a sense mathematics is the best possible exemplar of Brunerian structure; not only can the corpus of knowledge be adequately treated in terms of its structure but that structure can be defined in extraordinarily parsimonious terms. Mathematical structure is taken simply to mean "the relations between the elements and operations of a set" and mathematics can be seen to be the study of structure in this sense [155] (p.10). The 'new mathematics' is predicated on this premise. Bruner himself appears to have been satisfied that the structural approach to mathematics as interpreted by mathematicians and implemented in new curricula coincided in large measure with his structural approach to subjects. He has said that [152] (p.8):

> The scientists constructing curricula in physics and mathematics have been highly mindful of the problem of teaching the structure of their subjects, and it may be that their early successes have been due to this emphasis. Their emphasis upon structure has stimulated students of the learning process.

The new pedagogy obviously stimulated Bruner and while he was not the initiator of such reforms in mathematics education he has contributed immeasurably by providing them with a framework of cognitive theory [156]. The essence of Bruner's position, say interpreted for mathematics, is that *optimization of subsequent* *retention and transfer of learning occurs when the structure of mathematics is learned by discovery methods* [156].

The emphasis is on processes and principles as the most important things to be transferred. Thus the'best' way to learn mathematics is to 'discover' its structure i.e. come to grasp mathematical structure through discovery methods. There is reason to believe, therefore, that Bruner's conception of the structure of a subject and the above definition of mathematical structure are congruent. The affinity is obviously strengthened by Bruner's [93] (p.44) three-way characterization of the structure of any domain of knowledge:

> ...the *mode of representation* in which it is put, its *economy*, and its effective *power*. Mode, economy, and power vary in relation to different ages, to different "styles" among learners, and to different subject matters.

Bruner's disciples in mathematical education would support the proposition that the mode of representation of the once 'new maths' is accessible to all pupils of all ages, and that the economy and power of mathematical structure is unequalled as a means of structuring mathematics for all pupils of all ages.

The difficulty with this position is that the structure of the subject as Bruner sees it is defined in terms of the logical features of the subject. In general the logical features of a subject are insensitive to historico-cultural influences - in short they offer little or nothing by way of explanation as to how or why subjects have the specific character they have and which is now observed [154]. In relation to mathematics the problem is more serious. In accepting the mathematical structure approach to mathematics the logical features of the subject are uniquely characterized by *formal logic*, a deductive system on the classical model. This may be a bonus in terms of economy and power but it is singularly inappropriate pedagogically. The way structural elements such as leading ideas, key concepts, characteristic methods of inquiry and intellectual style fit together to promote a feeling of wholeness and interrelatedness may be intrinsically motivating but when all such activity is dominated by a single deductive system as in the structure approach to mathematics the intrinsic motivation is scarcely sustained and quickly evaporates. The danger for mathematics in such an approach is that mathematics will as a result be construed as a vast formal deductive system, static and displaying a finality which is altogether belied by mathematics in the making. It is an incomplete description at best, a description which is altogether inappropriate for pupils and teachers alike. Kline [120] is unequivocal in his condemnation, he says that:

> Far from being the pedagogically sound representation of mathematics, the deductive approach introduces distorted views of the subject. First of all, mathematics is primarily a creative activity, and this calls for imagination, geometric intuition, experimentation, judicious guessing, trial and error, the use of analogies of the vaguest sort, blundering and fumbling.

> ...Thus the concentration on the deductive approach omits the real activity.
>
> ...It [logic] is the last act in the development of a branch of mathematics and, as one wise professor put it, when it is performed the subject is ready for burial. Logic may be a standard and an obligation of mathematics but it is not the essence.
>
> ...After we have determined what properties mathematical concepts and operations must possess on the basis of the uses of these concepts and operations we *then* invent a logical structure, however artificial it must be, which yields these properties. Hence, the logic does *not* dictate the content of mathematics. The uses determine the logical structure. The logical organization is an afterthought.

Wilder [157] has this to say about the pedagogical role of the axiomatic method in setting up the natural and real number systems:

> But he should be aware that here the axiomatic method plays only a clarifying and investigative role; that so far as a *foundation* for the natural numbers, the real numbers, or set theory is concerned, only a relative characterization is achieved.

It is important for future teachers of mathematics at secondary level, where the demands on the teachers' knowledge of mathematics are considerable, that they be conversant with the structure of mathematics as a human creative process circumscribed and influenced by human limitations, environmental factors, motivations and prior history. In short mathematical structure is important for future teachers but it must not represent the sum total of a teachers' understanding of mathematics. And a pedagogical approach based only on the deductive method is inadequate to the task of preparing future mathematics teachers. Pedagogically, mathematical structure is inert; it only gives mathematics as a deductive system. The prior preparation of future mathematics teachers must be based on a *dynamic* interpretation of mathematics i.e. a conception of mathematics as *cultural* in the first instance. The structural approach to mathematics in that case must be based on the *dynamic structure* of mathematics i.e. the historico-cultural and evolutionary nature of mathematics as well as its logical structure. Unlike mathematical structure which was taught directly to pupils according to the deductive method the dynamic structure of mathematics is not directly accessible to pupils or students. If the preparation of mathematics teachers is to be based on a cultural approach to mathematics then ways must be found of accessing the dynamic structure of mathematics and using it in the education of student teachers. In short, a pedagogically sound representation of mathematics based on the dynamic structure of mathematics is what is required. If such a representation can be found then the subject-preparedness of the student-teacher in mathematics can be optimized in the direction of subsequent retention and transfer of learning by concentrating on the *dynamic structure* of mathematics. Such a programme successfully concluded would assure the adaptability of future mathematics teachers.

5. Culture and the dynamic structure of mathematics

It is clear from what has already been said that a cultural approach to mathematics as interpreted here is crucially dependent upon an appreciation of what is meant by the dynamic structure of mathematics. Consequently it is necessary to devote some time to explicating the relationship between culture and dynamic structure. Mathematics is embedded in culture and as such may be treated in anthropological terms as a cultural element subject to the processes of culture change and growth. Culture in this sense is as Wilder [158](p.17) put it:

> a collection of customs, rituals, beliefs, tools, *mores* and so on, called *cultural elements* possessed by a group of people who are related by some associative factor (or factors) such as common membership in a primitive tribe, geographical contiguity, or common occupation.

A cultural element such as mathematics may be considered the total culture as for example when the possessors of the cultural element mathematics, are taken as a group and considered bearers of a culture, in this case mathematics. If the primary purpose of schooling is to transmit culture, as many educators hold, then mathematics as a highly significant feature of modern culture merits transmission. Mathematics, therefore, is worthy of transmission to future generations because of its cultural significance. In what ways is mathematics culturally significant? The answer to that question must have important curricular implications for future mathematics teachers in their own education.

Mathematics as it is today represents but a stage in the evolution of mathematics as a cultural element. It is a creative work of man which is being constantly created and as such is an important part of man's culture and cultural heritage. Mathematics arose out of man's necessity to relate to his environment which invariably placed him in a problem situation. His desire to relate to and come to grips with his environment compelled him to overcome certain obstacles in pursuit of his objectives. Man's environment, therefore, was problematic in a general sense - man experienced a problem everytime he was motivated towards some obstructed objective [94]. Mathematics, therefore, may be viewed as part of man's intellectual response to his environment. Man continues to wrestle with his environment and seeks ways and means of explaining and conquering it. Mathematics has proved invaluable in this human enterprise and as a consequence its cultural importance derives in large measure from its usefulness. In Bruner's terms mathematics is the 'software' tool par excellence [93]. It has enabled man to come to grips with his environment by amplifying his powers for problem-solving, and presently its problem-solving potential in every sphere of human activity is largely unrealized. Wilder [158] (p.13) puts it differently but the meaning is essentially the same:

> However, the cultural significance and meaning of a human activity are not determined primarily by the motives of its individual practitioners. More important and fundamental from a cultural point of view is the role that the activity plays within the culture in which it is embedded. ...although the humanistic aspects of mathematics may be more important from the standpoint of the individual mathematician, *it is as a basic science that mathematics functions within our culture.*
>
> [my italics]

It is important to realize that mathematics is not confined to the *physical* environment. During the process of creating mathematics, mathematical concepts have been added to the world of reality "so that its domain of application included not only the physical environment, but the cultural (which includes the conceptual) environment"[159](p.41). Mathematics therefore, constitutes one of man's major conceptual tools for controlling his environment. The unparalleled success of mathematics in explicating the problems besetting man has led to its pervasiveness in modern society which can only be acknowledged by accepting mathematics as a major conceptual category of man in society.

Kline has taken up the idea of mathematics acting on the cultural environment. His [160] (p.29) thesis that "present-day Western civilization is distinguished from any other known to history by the extent to which mathematics has influenced contemporary life and thought" is ably and convincingly defended in his work Mathematics in Western Culture. Kline shows how mathematics influenced art, music, philosophy and religion. For Kline [160] (p.26)

> Mathematics is more than a method, an art, and a language. It is a body of knowledge with content that serves the physical and social scientist, the philosopher, the logician, and the artist; content that influences the doctrines of statesmen and theologians; content that satisfies the curiosity of the man who surveys the heavens and the man who muses on the sweetness of musical sounds; and content that has undeniably, if sometimes imperceptibly, shaped the course of modern history.

It would seem, therefore, that mathematics in its scientific and humanistic aspects has influenced and been influenced by culture. Often the recognition of these two aspects of mathematics is interpreted as an argument in favour of the division of mathematics into *pure* and *applied*. However, the cultural nature of mathematics allows us to dispense with such a dichotomy. As Wilder [159] (p.41) put it:

> Even though the dual nature of mathematics may seem to split it into one part that can be applied and one part that seems to be just something for professional mathematicians to play with, there is actually no clear separation. Both aspects of mathematics serve a scientific function, and if the so-called pure part, which ordinarily functions in the conceptual area of the world of reality, often becomes instrumental in the physical environment there should be no cause for wonder.

Potentially, therefore, all of mathematics, content and methods, is available for use in any given circumstance and one should not confine one's efforts to a habitual mode of analysis. Instead of a narrow compartmentalized approach every problem should be treated by any or all of the means available e.g. analytically, numerically or statistically. This involves acknowledging the *organic* nature of mathematics and culture.

It is clear that mathematics is culturally significant in two important respects, namely in its scientific and humanistic aspects. Now if the objective is to transmit culture then in order to avoid over burdening later generations with masses of information only the most important aspects should be transmitted. Thus efficient means must be found for passing on the scientific and humanistic aspects of mathematical culture. As pointed out earlier the problem is somewhat simplified since the scientific and humanistic aspects can be seen as different ways of dealing with reality which includes in addition to the physical environment the man-made universe of mathematical concepts. In this sense treating mathematics as a culture or as a cultural element encompasses all the dimensions of the problem.

Mathematics viewed as a culture or cultural element displays a certain structure which is the result of evolutionary forces. This structure can only be understood in the context of man's culture and against a backdrop of history. It is the living, dynamic or growth structure of the subject which not only shows how things are related in an efficient and powerful way but why they are related and how they came to be related. Again interest is centred on the most significant features and all the by-ways of history are not an important concern. *A cultural analysis of mathematics will yield important elements of cultural significance and these elements related in an efficient manner will constitute the dynamic structure of mathematics.* Such a structure represents an evolutionary stage in the process of mathematical evolution and is by its very nature suggestive of how mathematics is likely to grow in the near future. Most importantly the dynamic structure of mathematics is itself a concept in evolution and it characterizes mathematics at anytime in its evolution as a vibrantly creative human activity with a prior history and cultural setting.

The difficulty with this approach to the mathematics curriculum is to effect a cultural analysis of mathematics which is sufficiently comprehensive to serve as a basis for the curriculum. A second and equally important problem from the point of view of constructing an actual curriculum is that the features identified during analysis must be *generative* i.e. lend themselves to planning procedures. One obvious consequence of the latter condition is that the structure so devised is learnable and teachable.

The obvious starting point in such an exercise is to examine what other writers especially reputable mathematicians have said about mathematics as a culture or cultural element and/or what they might have written in relation to a cultural approach to mathematics. From such sources it may be possible in light of personal experience to construct a map of the important structural elements of mathematics and then to build a curriculum for the education of future teachers of secondary school mathematics around such a 'cultural map' [154]. Bondi [149] and Wilder [159] concur in their recommendations in this regard since each says that only the most significant concepts should be included. Bondi [161] suggests two broad guidelines: (1) only a few very interesting and fascinating topics should be chosen which do not require a boring build-up; (2) a clear statement of how a problem arises should be given since teaching should be less concerned with answers and more concerned with questions. Wilder [158] in another place has come close to providing the kind of cultural analysis required. By treating mathematics as a cultural element in evolution he has managed to identify special processes of evolution as they affected mathematics. He [158] (p.26) said:

> Thus, while it will be found that forces that are recognized as generally operative in the evolution of culture, such as diffusion, are quite as important in the case of mathematics, certain other forces, such as *generalization*, *consolidation*, and *diversification* ... have a special function in the evolution of mathematics. It can be expected, too, that *symbolization* will play a very important role in the evolution of mathematical concepts. For as a science becomes more abstract - and mathematics is notoriously *abstract* - its dependence on a well-devised symbolic apparatus becomes greater.
>
> [my italics]

Wilder [158](p.163) argues that eleven forces are operative in mathematical evolution and lists them as:

1. Enviornmental stress
   (a) Physical
   (b) Cultural
2. Hereditary stress
3. Symbolization
4. Diffusion
5. Abstraction
6. Generalization
7. Consolidation
8. Diversification
9. Cultural lag
10. Cultural resistance
11. Selection

Finally, Wilder suggests that these forces might obey certain laws which themselves are worthy of study with a view to their justification or refutation. These laws, for example, govern the evolution of mathematical concepts in such a way that only useful and fruitful concepts will evolve. However, general concepts are more likely to be preserved than the particular concepts they consolidate.

The needs of the host culture too, affect the evolution of mathematical concepts. In general mathematics will respond to the needs of the host culture. In this context, the pervasiveness of mathematics is most pronounced in complex and developed societies because such societies place more varied and intense demands on mathematics. However, if the cultural environment is static then it will stifle the development of mathematics. Yet despite various constraints mathematical concepts continue to evolve,and will continue to evolve, subject to certain contingencies.

The author, therefore, proposes to construct a cultural-map curriculum by defining curriculum content as a kind of chart of mathematical culture. Such mathematical content will obviously be influenced, in view of what has been said by the mathematical subculture and the host culture. On the basis of the analysis already made, the author believes that it is possible to identify and interrelate the fundamental tendencies and principal features of contemporary mathematical culture. By so doing one is also acknowledging the influence of and existence of important features in the host culture.

CHAPTER IX

A NEW RATIONALE

The author's case for a new rationale for the education of mathematics teachers for Irish secondary schools was presented in Chapter VIII. There he argued for a new approach to teacher education in Ireland based on his 'cultural approach' to mathematics. In the author's view such an approach requires that a cultural-map curriculum of mathematics be constructed for use in the Irish context. The author proposes to accomplish this by a direct approach to the mathematical subculture itself and its host culture as opposed to treating mathematics as a structure of knowledge. ~~embedded in culture.~~ This approach is calculated to yield the principal features of mathematics which are of interest educationally and a set of procedures for learning about and assessing and where desirable modifying the culture. The first step in the process is to use the new approach to identify the principal features of mathematics. This must be followed by an attempt to devise a mathematics curriculum incorporating the important features already identified in the previous process. And finally, if possible, the curriculum so devised must be implemented under actual working conditions. It is only in this way that one can justify a particular educational philosophy since teaching in the author's view is an eminently *practical* occupation. The rest of this chapter is devoted to describing and analysing the author's attempts to translate his rationale into a practicable programme of mathematics at Thomond College for the initial training of mathematics teachers for Irish schools.

1. A Cultural-map curriculum of mathematics

The author believes that the most obvious but nevertheless the most significant fact that the cultural analysis of mathematics yields is that mathematics is *evolving*. It is significant, too, in this context that the *rate of change* is greater now than ever previously in the history of mathematics. It is a fact that more new mathematics has been created in this century than in all the previous ages combined. At least two important curricular implications for the mathematics curriculum of future mathematics teachers derive from these considerations: (1) mathematics teachers must appreciate the evolutionary i.e. non-static nature of mathematics; and (2) mathematics teachers themselves must learn mathematics in such a way as will enable them to keep abreast of developments in mathematics as they affect the school situation in Ireland.

Two other aspects of mathematics are revealed by cultural analysis, namely, the *humanistic* and *scientific* aspects. In the author's opinion, the case for each is so cogent that neither can be neglected for curriculum making purposes in the Irish context. However, in view of the technological nature of developed societies - and Ireland aspires to that status - *priority* must be given to the scientific view of mathematics since mathematics functions as a basic science in such societies.

The anthropological theory of culture change and growth points to a universal phenomenon in the evolution of culture viz. the need for a mature culture to explain its origins. Mathematics as a cultural element, subculture or culture has achieved the requisite maturity and therefore a search for its origins or foundations must be in progress. In fact much work has been carried on in what might be termed the foundations of mathematics and such studies have become increasingly important in modern times. Since such considerations are culturally important *they must be reflected in the cultural-map curriculum of mathematics.*

Here it is prudent to pause and consolidate the work already done. It is important to bear in mind that the cultural analysis of mathematics must serve two purposes: (1) it must highlight features of mathematics which are culturally significant; and (2) it must provide a means of learning about and assessing these features. Thus far four features of mathematics have been highlighted by cultural analysis. They are: (1) its non-static character; (2) its scientific aspect; (3) its humanistic aspect; (4) its tendency to examine and study its origins or foundations. In the same context it is legitimate to apply the ideas of culture change to mathematics. In so doing various mathematical processes can be identified which were particularly significant in the evolution of mathematics. These processes are obviously part of the culture and as such must be culturally significant. Such processes which clearly provide means of learning about and assessing mathematics in a cultural context are obviously important from a curriculum point of view. They lend themselves, too, to an explanation of the important features of mathematics already identified.

The author proposes to concentrate on five *processes* which are especially important in the evolution of mathematics - *generalization, consolidation, diversification, symbolization* and *abstraction*. However, this concentration does not exclude other processes which can be inferred from other culturally significant features of mathematics. In this context it is particularly appropriate to infer such processes as *problem formulation and solution, modelling,* symbolization abstraction etc from the scientific aspect of mathematics. From the study of the foundations of mathematics one can infer the importance of all five listed processes and in addition see the need for introducing the axiomatic method. In fact the author believes all these processes are evident, generally speaking, to a greater or lesser degree in every aspect of mathematics that is considered, thereby underlining their central importance for the mathematics curriculum. These are the processes of mathematical evolution and as such merit study.

By returning momentarily to the non-static nature of mathematics one is led to a consideration of non-static mathematical concepts i.e. evolving concepts. Any consideration of mathematics must include a discussion of its concepts. A cultural approach to mathematics must be based on *significant* mathematical concepts only. An analysis of Wilder's first three laws leads to the same conclusion since: (1) only useful concepts will evolve; (2) the admissibility and acceptance of a concept will be decided on its fruitfulness; (3) the usefulness of a concept generally ensures its continued evolution. The significance of such ideas for curriculum building are less clear-cut than others encountered. Obviously, the curriculum must be based on significant concepts. As this relates to inclusion of relatively old material there is no problem since the laws of evolution have 'guaranteed' that only significant concepts have evolved and only those will be in the mainstream of mathematics. However, the question becomes more difficult in relation to mathematics that is new. In that case only the useful or fruitful concepts must be included and these concepts must be identified by whatever means by the curriculum maker, and identification process rendered less difficult against a backdrop of Wilder's laws.

The ideas discussed in the preceding paragraphs lead to a curriculum design which is deemed to be particularly appropriate for the initial training of future mathematics teachers for Irish secondary schools. On the basis of what has already been said their curriculum should be built on the following elements, which constitute the 'cultural map':

- *Significant* mathematical concepts and skills
- *Developmental Studies* of the foundations of mathematics
- *Mathematical Processes* such as (a) problem formulation/solution, modelling, symbolization, abstraction, generalization, consolidation, diversification, and (b) mathematical methods such as inductive reasoning, deductive reasoning and the axiomatic method, reasoning by analogy, intuitive and heuristic reasoning.

These elements then are elements of the dynamic structure of mathematics. The premise is that Irish student-teachers will have developed their mathematical powers sufficiently as a result of having experienced properly organized and presented studies in these areas, that they will be able to profit from further education in mathematics, and if need be, be able to continue their mathematics education profitably on their own.

It is important to note that in all that has been said about a cultural approach to mathematics the author has expressed no preference for one teaching method over another. Unlike Bruner's structural approach which sees the optimization of transfer occurring only if discovery methods are used (although Bruner [162] in recent years seems to have relaxed his emphasis on structure and discovery) *the teaching of the dynamic structure of mathematics admits of whatever pedagogical methods are thought appropriate and desirable.* In fact the author has argued in another place (Chapter VII) for a deliberately implemented policy of using a variety of different teaching methods. Such an attitude is felt to be important for a variety of reasons but especially because: (1) it allows student-teachers to experience different teaching styles in their own education; (2) it makes more possibilities for the individualization of instruction available to students in their own learning.

2. Models and Modelling: A pedagogical representation of mathematics

An efficient means of transmitting mathematics must be found which is consonant with the cultural-map curriculum. For this purpose the author decided to construct a *pedagogical representation* of mathematics. Such a conceptual construct serves the purpose of providing a coherent framework for the mathematics education of future mathematics teachers. It offers a broad but necessarily circumscribed view of what mathematics is and how it came to be so and does this in such a way that student-teachers have an adequate and reliable means of future personal development in mathematics. In short, it integrates the elements discovered through cultural analysis into a coherent framework of principles and basic ideas in such a way that themes are evident and explicable and relationships with other subjects are obvious and intelligible. Such a representation must obviously be rich in powers of explanation and problem-solving and relatable to contemporary problems and issues. The pedagogical representation is essentially a *conceptual model* of mathematics, purpose-built for pedagogical reasons. It is an *idealized* representation of reality viz. mathematics as a cultural element and as such is subject to all the limitations of models. The features of the cultural map incorporate all the simplifying assumptions of the model and hopefully all the relevant features from a pedagogical point of view have been retained. The model, therefore, offers a view of mathematics which can be criticized and in a sense its validity can be gauged from its success in providing an integrated coherent framework for mathematics as a cultural element.

It is obvious that such a pedagogical model will incorporate its author's values and beliefs concerning the nature of mathematics, its role and its educational value. In essence, the pedagogical representation so constructed manifests a system of beliefs concerning mathematics, culture and mathematical education. It might be seen as an *ideological* approach to mathematics. In a sense it is the author's ideology of mathematics in this case shaped by the Irish environment which the student-teacher is invited to share on the pedagogical assumption that the system allows for the development in the student-teacher of critical faculties which enable him to accept, reject, modify or substitute an alternate view of mathematics.

The pedagogical representation of mathematics proposed here by the author is based on the psychological explanation of how man copes with his environment. According to Bruner [153] (p.18):

> Man constructs models of his world, not only templates that represent what he encounters and in what context, but also ones that permit him to go beyond them. He learns the world in a way that enables him to make predictions of what comes next by matching a few milliseconds of what is now experienced to a stored model and reading the rest from the model.

The models are stored theories of the world and man operates on the stored models rather than directly on the world itself. He enlists the aid of many intellectual tools such as language and mathematics in this activity and both the models and the tools are provided by culture. It is important to realize that man creates models before he creates tools [153]. Now the extent to which this modelling activity has been explicitly systematized in the general problem context of man interacting with his environment it has become fertile ground for the development of mathematics. Consequently, the author bases his pedagogical representation of mathematics which is presented in the following paragraphs on *models* and *modelling*.

In this context a very general definition of model is proposed. A model is simply a representation of any situation, system or thing [94]. Models may be classed into two broad categories viz. *conceptual* models or *physical* models. A model aeroplane is an example of a physical model as is a paper mache model of a building project. If a model is not physical then it is conceptual. The primary function of models is to give shape, structure and pattern to our ideas about reality. They provide means for holding and displaying all the important features of the situation and their relationships for the purpose of operating on them [94]. Models in this general sense, are influenced by culture. They arise out of each individual's image of the world. Image in this sense is taken to mean [96] (p.17):

> The Image is all the accumulated, organized knowledge that the organism [man] has about itself and its world. The Image consists of a great deal more than imagery, of course... It includes everything the organism has learned - his values as well as his facts - organized by whatever concepts, images, or relations he has been able to master.

It is obvious then that models are dependent upon the culture and since culture itself is evolving it is fair to expect that the models of one generation especially the conceptual models will vary significantly from models of previous generations. For the purposes of constructing the pedagogical representation of mathematics the author sees conceptual models *only* as being relevant.

Man relates to his environment in terms of conceptual models. It follows that man's attempts to understand his universe must be *based* on his conceptual models. And as Hirst and Rhodes [163] (p.xi) observed "In many cases the drive to understand phenomena has come from a desire to control them or at least to make predictions about them". But conceptual models are based on concepts, specifically those concepts which the individual can master, or invent. Concepts are available in the culture and new concepts become part of the culture. Thus concepts are part of reality. It is relevant to ask in this context which concepts are mathematical concepts? The answer to this important question is contained in the not so obvious reply - mathematical concepts are those concepts which belong to mathematics. What this circuitous reply is intended to convey is the fact that potentially *all* concepts are mathematical concepts and become bona fide mathematical concepts when they are admitted to mathematics. Traditionally mathematics was deemed to deal with number and form but through the centuries many new concepts have been added to mathematics due to various evolutionary stresses. In its beginnings, mathematics derived its concepts directly from the external world by a process of abstraction. But once these mathematical concepts were admitted to the world of reality they could be applied to other concepts so that the domain of application was enlarged to encompass the conceptual as well as the physical environment. In the modelling context, if only mathematical concepts are used to represent reality then the conceptual models so devised are strictly speaking, *mathematical models*. It follows that all mathematical models are conceptual models but not all conceptual models are mathematical models. There is a sense, therefore, in which conceptual models may be classed according to the concepts used in the modelling process. In this way conceptual models may be designated mathematical, psychological, chemical, biological or indeed physico-chemical or bio-physical.

For the purposes of this discussion the author treats reality as having two aspects only, namely, mathematical reality and non-mathematical reality. Man relates to the conceptual reality 'mathematics' by constructing conceptual models of mathematics. He may choose to treat the mathematical reality in terms of non-mathematical concepts only, mathematical concepts only, or mixed mathematical and non-mathematical concepts. In fact history shows that mathematics has benefitted from all these approaches. For example, Cantor constructed the language of sets or set theory on the basis of two everyday *non-mathematical concepts*, set and element of a set, in order to explain certain aspects of mathematics. However, in this case when the set theory i.e. the conceptual model based on the language of sets, proved useful as a basis for the number system, for example, set and element were admitted as mathematical concepts and set theory became a fully fledged mathematical model. Mathematics abounds with instances where mathematical concepts have been applied to mathematical concepts e.g. group theory. And finally, there are numerous instances where the conceptual model involved the application of mathematical concepts to non-mathematical concepts. A case in point is the classical definition of probability. In all these cases the resultant concepts were admitted into mathematics. However, this does not have to be so. This analysis, for example, does not exclude conceptual models of mathematics which might be philosophical or psychological. In fact the pedagogical representation proposed here by the author is a psycho-mathematical model of mathematics. But it is not part of mathematics. It is a fact, however, that much of modern mathematics has resulted from the application of mathematical concepts to mathematics itself i.e. a second order abstraction process. And mathematics seems to be progressing in the direction of greater abstraction.

When mathematical modelling became a *purposeful* activity of the mathematical community it became an important means of *generating* new mathematics. Modelling in this sense became purposeful when mathematics attained the status of a science. This occurred when mathematics was applied systematically to reality - the cultural (including the conceptual) and physical environment. This happened many centuries ago since Babylonian number theory, for example, attained the status of a science of numbers. Mathematics has been remarkably successful in its role as a science as applied to different aspects of reality. Following the division previously proposed it is expedient now to discuss mathematical models of mathematical reality and mathematical models of non-mathematical reality.

The mathematical models obtained when mathematical concepts were applied to mathematics were based on existing mathematical models. In this way existing models came to be incorporated into new models of mathematics and so the process went on and still goes on today. The modelling processes as it were became the building blocks for other modelling processes [164]. In this way mathematics may be viewed as *self-modelling*. For example, arithmetic may be viewed as a model for algebra and axiom systems as models for various branches of mathematics. The concept of structure is currently used as a means of modelling mathematics. In this sense one speaks of mathematical *structures* as opposed to mathematical *structure* and mathematics is, as it were, populated by a variety of structures including function, group, vector space etc. Mathematics evolved its own means of modelling structure in terms of axiom systems and currently the axiomatic method is an important tool for analysing and extending mathematics [157]. These mathematical models based on axiom systems display remarkable characteristics. Some have been purpose-built such as Peano's Axioms for the Natural Number System and as such generate only the natural number system. Since they have only a single concrete realization they are said to be *univalent*. Others which have been considered to be of mathematical interest only have proved remarkably successful in explicating non-mathematical reality as instanced by linear operators and Hilbert Space which serve as a conceptual model for Quantum Mechanics or Riemannian geometry which is the conceptual model for General Relativity Theory. Such structures have more than one concrete realiization, and be they mathematical or non-mathematical realizations, they are referred to as *multivalent* structures. Multivalent structures are especially important in mathematics since they facilitate *consolidation* of mathematics by effecting a unification of diverse areas of mathematics. In fact, one very influential group of mathematicians viz. Bourbaki sees mathematics as resting on three fundamental structures. These are algebraic structures, structures of order and topological structures. However, this model of mathematics is elastic since the list of three fundamental structures is not exhaustive. The number might be increased as mathematics evolves. Such attempts illustrate very powerfully the self-modelling aspect of mathematics.

Turning now to mathematical models of non-mathematical reality traditional areas of applied mathematics stand out and can all be included under mathematics in the context of the physical sciences. However, mathematics has penetrated many areas for long untouched by mathematics. Reality, therefore, in all its aspects is a rich source of mathematical models. The widespread applicability of mathematics and the unprecedented success of its methods in explicating reality have led to interest in the processes of applying mathematics. Consequently the mathematical modelling process hitherto implicitly applied became the focus of study. The idea of a mathematical model was made explicit and the modelling process gained widespread attention. Lee [165] offered a working definition of applied mathematics based on modelling:

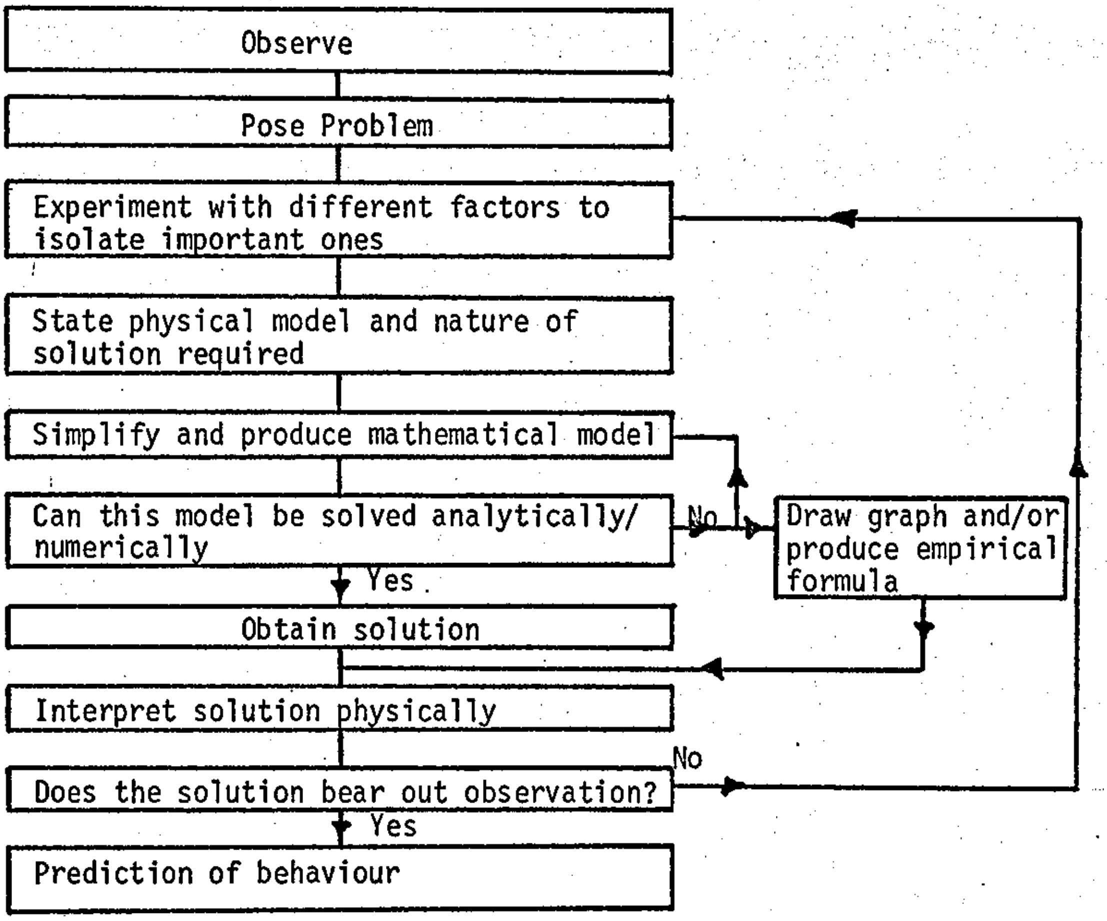
> If applied mathematics can no longer be regarded as mathematics in the context of the physical sciences, we must seek a substitute working definition and I have chosen to define applied mathematics as the interpretation of any mathematical structure as a model of a system in the real world. A broad, spiritualist definition, it works reasonably well, except perhaps on the question of computability.

More recently some authors Ford [166] and Lancaster [167] have offered the modelling process as a unifying philosophy for applied mathematics. *The author's position is that the modelling process may be regarded - when applied to reality including mathematical reality - as a unifying philosophy for mathematics.*

Typically the modelling process is used to investigate a certain phenomenon of the real world. Brown [168] for example, has devised a set of 'real' problems for use in introducing secondary school mathematics teachers to model building. However, real-life phenomena are generally so complicated that only a *few* important features can be represented and accounted for by the mathematical methods available. In that event *simplifying assumptions* are made. This is the point of departure from the real world and the beginning of the modelling process. The problem or situation has been *idealized* subject to two important constraints: (1) all the relevant features have been retained; and (2) the idealized problem has a solution that can be found [167]. The next stage in the process consists of representing the idealized problem in terms of mathematical concepts i.e. constructing the mathematical model. Then the mathematical model is solved yielding solutions which are interpreted in the context of the real world situation. And finally the results are compared with observations. Lancaster [167] (p.6) summarizes the procedure in the following way:

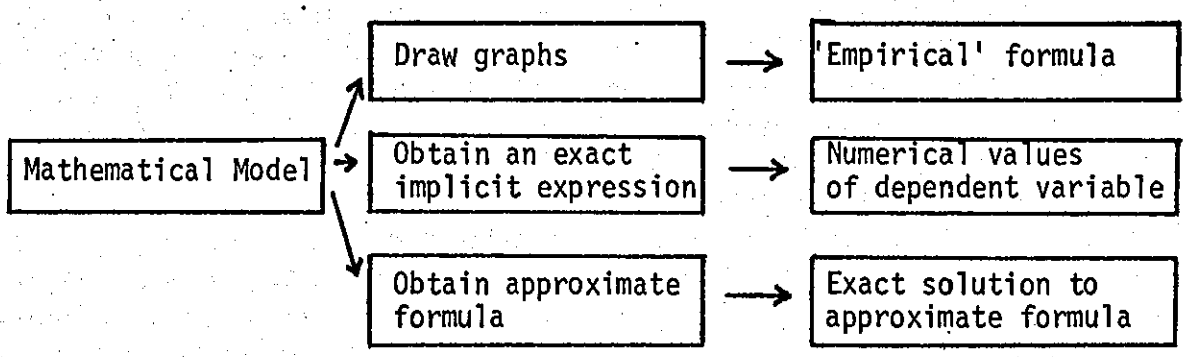
> Let us now summarize the steps in this general procedure of applied mathematics:
>
> 1. Attention is focussed on a phenomenon of the real world. Certain features or patterns of behaviour are to be explained or predicted.
>
> 2. A model is constructed in two steps:
>
>   (a) The phenomenon is idealized
>   (b) A sufficient number of consistent conditions are imposed
>
> 3. Mathematical reasoning is applied to obtain appropriate conclusions concerning the model.
>
> 4. The conclusions concerning the model are interpreted in the real-world situation.
>
> 5. The results are compared with observation.

Generally speaking, the steps outlined by Lancaster are repeated as solutions have to be refined or improved. The *iterative* nature of models is appropriately captured by Bajpai [169] in his description of the process as applied to scientific and engineering problems (Fig 9.1). The problems attendant upon solving the mathematical models are dealt with explicitly by Bajpai [169] and the whole process is, therefore, fully elaborated. (Fig 9.2). Both descriptions, however, capture the essence of the process. Matthews and Bausor [170] have encapsulated its essence in the following quote: "This is the essence of mathematical modelling: reality - model - reality, or briefly (R) - (M) - (R)." The latter characterization of the modelling process accommodates the iterative nature of models by a simple literal string (R)-(M)-(R)-(M)-(R)-... Thus mathematics as applied to non-mathematical reality may be reasonably and effectively explained in terms of the modelling process.



THE MODELLING PROCESS

FIGURE 9.1



SOLVING THE MATHEMATICAL MODEL

FIGURE 9.2

It is indeed true that mathematics has been singularly successful in modelling real situations but much mathematics has been generated by the requirements of models. The Calculus is such a conceptual model which arose in response to the needs of dynamics. Reality, therefore, in all its aspects is generative of new mathematics via the modelling process. Consequently, the author no longer sees any need to create an artificial division of mathematics into pure and applied; these aspects of mathematics arise out of the scientific function of mathematics.

3. Validating the pedagogical model

Now it has been demonstrated in the preceding paragraphs that a pedagogical representation of mathematics based on models and modelling is a viable proposition. It remains to show that such a pedagogical representation is indeed *valid*. Some words of explanation are needed here. The pedagogical model proposed does not have to constitute a *definition* of mathematics; it is a model based on the *nature* of mathematics and as such it is as legitimate as any other person's view of the nature of mathematics. However, the model does have to meet certain specifications, in this case it must display the dynamic structure of mathematics as encapsulated in the curriculum design derived from the cultural analysis. The author's contention that it does so is supported by the following remarks. Firstly, the pedagogical model does generate sufficient mathematics for a viable programme for the education of future mathematics teachers and skill in modelling would indeed serve teachers in the future as a means of advancing their own mathematics education. Secondly, modelling in the sense described involves the use of all the mathematical processes included in the design as well as significant concepts. Thirdly, the models are culture-dependent and as such the origin and development of models would serve as a vehicle for the developmental studies of foundations of mathematics which of necessity involves *historical* studies.

Finally, it is the author's firm belief - based on the analysis already presented and his limited personal experience with programmes at Thomond College - that the modelling process itself is a powerful pedagogical tool for teaching mathematics and teaching the dynamic structure of mathematics. Such an approach in fact constitutes a cultural approach to mathematics. Thus the author's pedagogical representation may be validated in all important respects except one - only by constructing an actual programme and running it can one subsequently decide whether the Irish mathematics teachers so trained are adaptable. Attention will now be directed to this crucial test of the cultural approach to mathematics.

4. The new-style mathematics curriculum

Many of the principles and ideas enunciated above have been incorporated into programmes conducted by the author at Thomond College of Education during the period 1975-78. In fact the author believes that his programmes which have been extensively analysed in Chapter VI have captured the essence of the new approach. The syllabuses for the programme are presented in Appendix B and Appendix E contains a set of examination papers set for the students on the programme in 1978 and preceding years. Thus the practical business of writing syllabuses and implementing courses has already been tackled by the author. This means in effect that syllabuses have been drawn up and taught to Irish student-teachers. These students have received awards - in each case degree awards - from validating bodies e.g. the National Council for Educational Awards and the National University and are now - some sixteen of them - in the schools teaching mathematics to Irish children. Reports from various sources including the Inspectorate of the Irish Department of Education concerning these teachers are positive and encouraging.

The entire programme (see Appendix B for mathematics syllabuses) was critically examined for the National University in 1977 by Professor P D Barry from University College Cork and his team. The programme was validated without alteration and the students were subsequently awarded a classified B.Ed degree of the National University. This programme is the current programme at Thomond College and has been accepted for validation by the National Council for Educational Awards. However, the author feels that the programme can be improved by including courses in the history of mathematics and the 1977 programme has been expanded accordingly to include three short courses in the History and Nature of Mathematics. Encouraged by the initial programme's favourable reception by the awards bodies and students, the author is submitting the expanded programme to the National Council for Educational Awards for validation in December 1978. The mathematics course content for the expanded programme is defined by the totality of syllabuses contained in Appendices B and D.

Based on this limited personal experience circumscribed though it was by local circumstances such as very small student numbers, certain definite conclusions can be made. These conclusions, however, are not based on statistical evidence but are nevertheless valid as far as they go in the Irish context. The author's experiences show, for example, that certain things never before attempted in Ireland can be done because they have been done by the author at Thomond College during the past few years. The author has provided a viable alternative to university-based training for Irish mathematics teachers. It is different and in the author's view it is a better preparation in many respects for mathematics teaching in Irish secondary schools. Students have graduated from the programme and are now teaching in the schools and initial reaction from the schools and the Inspectorate has been favourable. No longer is it necessary to speculate about the *possibility* of doing such things in Ireland; they have been shown to be feasible under actual conditions in an Irish College of Education. But perhaps it is more important in the national context that these efforts have been the work of an *Irish* researcher conducted in an *Irish* college on behalf of *Irish* student-teachers in the interests of improving mathematical education in *Ireland*.

The Mathematics Programme as devised by the author at Thomond College, and discussed at length in Chapter VI, was based on significant concepts only from the very outset. A ruthless pruning of material was necessary in order to effect this and courses so devised looked quite different from university courses in mathematics. Courses such as Computer Studies, Graph Theory and Transformation Geometry were novel in the Irish teacher education context but were nevertheless included from the beginning in 1975. Other courses such as the Mathematics Seminar and the History and Nature of Mathematics were incorporated later in an attempt to place mathematics - more firmly and explicitly for the student - in a human historico-cultural context. The whole approach was based on problem-solving as a fundamental activity and modelling became the focal point of the whole programme. Modelling was developed in the first or second year as a credible explanation of the mathematics/science interface, and taught in conjunction with the students' science courses in physics, chemistry and biology. Subsequently the author concentrated on modelling as a fundamental theme in the programme, in fact considerable effort was devoted in each course, and in special courses such as Algebraic Structures, to explicating the entire programme and mathematics in general in terms of models. These efforts were directed towards creating a perspective in the student in which he could see his mathematics education now and in the future developing thereby ensuring his adaptability. The main vehicle for such efforts was the Mathematics Seminar which has been described in detail in Chapter VI. However, this activity was not exclusive to the seminar since much foundational work was included in every course as the opportunity arose and historical notes, biographical and otherwise, were inserted.

During this time the author consciously and deliberately promoted and insisted on mastery of the mathematics involved. His conviction was, and still is, that no secondary teacher of mathematics can perform adequately in the school situation without having a thorough command of a considerable amount of mathematics - mathematics in advance of what he actually teaches. In order to achieve this objective the author devoted much attention to teaching methods and a variety of styles was deliberately used so that student-teachers might experience such styles first-hand in their own education and maximize their own mathematics learning. Students were introduced to programmed texts, experienced a PSI-style course in Computer Studies and attended a Mathematics Seminar as part of a programme which was otherwise taught in the usual manner by lecture/tutorial and/or workshop sessions. Ultimately the author was concerned that his students i.e. future teachers would not only know enough mathematics but also know *about* mathematics.

Early indications - and students who have experienced variants of the programme have been in the schools since 1975 - are encouraging if school managers and school inspectors are to be believed. It is on this basis together with the quality control - and in the absence of large numbers one must concentrate on quality - exercised by the validating bodies and reinforced by the author's own precaution of seeking outside opinion on the quality of the programme, that leads the author to be cautiously optimistic. In the circumstances and in the Irish context the author believes that his new approach and his pedagogical representation have been validated in a reasonable and adequate way.

CHAPTER X

CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

The research described in the previous chapters was directed towards improving the mathematics education of future mathematics teachers for Irish secondary schools *in their initial training.* A synthesis based on all the previous work was achieved in Chapters VIII and IX and for this reason it is proposed to confine this the concluding chapter of the thesis mainly to considerations arising from those chapters, although not exclusively. The major conclusions, therefore, can be seen as deriving from Chapters VIII and IX and are obviously related to the initial education of mathematics teachers for Irish secondary schools. However, these are set out and discussed not as conclusions but as *principles* on which to base future action.

1. Advancing mathematical education in Ireland - Some important principles

The changed and changing nature of our society and the ever increasing rate of such change motivated an examination of the ramifications of such circumstances for teacher education, specifically the education of future mathematics teachers for Irish schools. In view of the fact that in-service education facilities are practically non-existent in Ireland and unlikely to improve sufficiently and be maintained at an adequate level certain conclusions were inevitable. These are encapsulated in Principles 1 and 2.

Principle 1. *The initial training of mathematics teachers for Irish secondary schools must be viewed as the most important aspect of his* *training, and treated and provided for accordingly.*

The second principle relates to the aim of such initial education and in view of the demands placed on it the conclusion is that:

<u>*Principle 2.*</u> *The initial education in mathematics must be so designed as to promote adaptability in the mathematics teacher i.e. optimize the potential for transfer of learning.*

Such an emphasis demands a new approach to the initial education of future mathematics teachers, an approach calculated to promote maximum transfer of learning.

<u>*Principle 3.*</u> *Maximum transfer of learning occurs by teaching not the structure but the dynamic structure of mathematics as defined by cultural analysis.*

It is obvious that the success of such an approach is crucially dependent upon the effectiveness of the teaching. The next principle is concerned with just that point. The conclusion based on the work carried out is that there is no optimum method for teaching dynamic structure as here defined. This view is at variance with Bruner who bases the primacy of discovery methods on the developmental psychology of Piaget. The implications for teacher education are obvious.

<u>*Principle 4.*</u> *Student-teachers, and this includes future mathematics teachers, should experience a deliberately planned variety of teaching methods in their own initial education.*

The refusal to accept the primacy of one teaching method over another does not exclude the existence of a desired framework for such teaching or indeed preclude the possibility of a facilitating framework. It is, therefore, proposed that the desired effect and its attainment can be facilitated by a purpose-built pedagogical representation of mathematics, provided suitable precautions are taken.

Principle 5. *The initial education of future mathematics teachers in the direction of adaptability is significantly enhanced in the context of an ideology of mathematics incorporating the dynamic structure of mathematics and based on models and modelling as a unifying philosophy for an organic view of mathematics.*

Still on the theme of teaching mathematics to future mathematics teachers it has become obvious on the basis of the analysis presented in Chapter VI that:

Principle 6. *Mathematics need not necessarily be taught to future mathematics teachers as it would be to future mathematicians.*

Two points arising from the principles or conclusions just presented need further elaboration. Throughout the thesis there has been an emphasis on the *initial education* of future mathematics teachers in mathematics and the research concludes with an *ideology of mathematics*. With reference to the first point, at first glance it appears to be totally contrary to recent trends de-emphasizing initial training in favour of more and better provision for the teachers' continuing education. The James Report [171] and the Report of The Royal Society on The Training and Professional Life of Mathematics Teachers [15] are two such recent reports. While it is true that provision must be made for the continuing education of mathematics teachers the opportunity of maximizing the benefits of such training should not be wasted. The benefits of further education can only be optimized against a background of an adequate initial education. *It is the initial education of future mathematics teachers, therefore, which assumes primacy.* Further, the initial education is critically important in those instances where further education provision is lacking or non-existent and in such cases the continuing education of the mathematics teacher is strictly speaking in his own hands.

The second point arising from the preceding discussions is potentially more controversial than the first. Ideology is an emotive term and the notion of developing an ideology of mathematics is perhaps forbidding. However, what the author proposes is to *displace* a current ideology of modern mathematics based on the logical structure of mathematics and the axiomatic method by a more dynamic ideology of mathematics based on a cultural approach to mathematics. Ormell [172] for example was not happy with the structure approach to mathematics and proposed an alternative approach based on applicable mathematics. In any event ideology is not new in mathematics teaching since most textbook writers advocate a point of view based on their beliefs and values regarding mathematics and mathematics teaching, and the 'new maths' long ago assumed the aura of a modern ideology. *What is new is the conscious effort to promote ideological thinking as a means of improving the mathematics education of teachers in training in Ireland.*

2. <u>A national plan for the advancement of mathematical education in Ireland</u>

The research concluded in this thesis has implications for mathematical education generally in Ireland, and it is in that broader context the following remarks are made with a view to extending the benefits of such work. Much of the research as already indicated, is based on a small-scale project at

Thomond College - only sixteen students have completed the programme to date. Nevertheless the programme, despite its scale, is national in design and impact since it was designed for student-teachers who subsequently qualified to teach mathematics in Irish secondary schools. The very *existence* of the programme is significant in the Irish context since *it represents the first and only full-scale alternative to university training for secondary mathematics teachers and as such adds a new dimension to the training of mathematics teachers in Ireland.* In such circumstances it is obvious that the conclusions derived from the research pertain directly and in the first instance to the Irish problem, namely, improving the initial mathematics education of future mathematics teachers as a means of improving mathematical education generally. However, despite its national character there is much that is independent of the system and as such transcends the local scene. Insofar as the research described here transcends the Irish scene then it is hoped that it is a small contribution to the literature in mathematical education.

It is obvious now after some years in operation - having been validated during that time by the National University and the National Council for Educational Awards - that the Mathematics Programme at Thomond College is a *viable alternative* to the university training of secondary school mathematics teachers. However, it does not offer a *full alternative* to university training for such teachers since as presently constituted Thomond College caters for the education of *specialist* teachers only and its programmes therefore are not generally available. On the basis of research completed, the desirability of extending the benefits of such training to a wider student population merits examination. *The author concludes that such training should be made available generally by opening the Mathematics Programme at Thomond College to the whole student*

student population. This could be effected by having mathematics officially designated a *special subject* i.e. a subject requiring special attention due to its fundamental importance for the school curriculum and society generally. This would entail making a special case for mathematics, a position which Ollerenshaw [173] says could be defended. The ultimate objective is *not* to concentrate *all* the provision for the initial training of secondary mathematics teachers at Thomond College but to use the available facilities there - suitably augmented - to prepare *ab initio* a cadre of very well educated and trained mathematics teachers who could be distributed throughout the system according to a pre-conceived plan, *on an on-going basis*. A selected intake of perhaps 15-20 students annually would suffice - the actual number could be determined by research.

By suitably augmenting the facilities for mathematical education at Thomond College of Education - and this could be accomplished in a variety of ways - the resulting impact on mathematical education in Ireland could be significant. For example the College has already been designated as a 'national centre' for in-service education of teachers [87]. By combining the pre-service role already mentioned with the in-service role officially anticipated in a modest research unit[1] - say a centre for the improvement of instruction in mathematics comprising a full-time staff of 3-5 experts in mathematical education including a permanent director - the return measured in terms of improved mathematical education in the schools

---

1. Centres like CAMET or the Centre for Science Education at Chelsea College, University of London, or the Shell Centre at the University of Nottingham are what the author has in mind.

would be great. For such a modest outlay involving no capital or administrative costs, since the centre would be housed by the College and administration shared, a continuing programme of teaching and research would be feasible, both in the pre-service and in-service aspects of teacher education in mathematics. The principal functions of such a centre would be:

1. To conduct research in mathematical education with special reference to the needs of Ireland in this regard

2. To convert available expertise and research on an on-going basis into a viable programme for the initial mathematical education of future mathematics teachers for Irish secondary schools and to conduct such a programme at the centre

3. To plan, co-ordinate and teach in-service courses for mathematics teachers especially teachers of mathematics in secondary schools on an on-going basis and to devise ways and means of optimizing the benefits of in-service courses for mathematics teachers and the education system generally.

Already the author has laid a foundation for research in the area of mathematical education as evidenced by this thesis. Such an expert group might want to consider other conclusions deriving from this research project and suggested directions for further research. One concern of the author has been the area of in-service provision for mathematics teachers and ways and means of improving the qualifications of mathematics teachers already in service. These concerns and others motivated the work on self-paced study discussed in Chapter VII, and the new rationale presented in Chapter IX. However, the work reported in Chapter VII is of more immediate concern here. One way of reaching teachers throughout the year despite their geographical location is by means of PSI-type courses developed at, and distributed and monitored from a central location. Even at a small centre such an approach is feasible for one course at a time with a limited number of respondents. *An efficient system of extending such a course to a large number of teachers and the nature and design of the course is an area where further research is needed.* However such a system must be an integral part of a coherent approach to in-service education and such a plan is not a 'given', it must be researched systematically. The author proposes a plan based on a two-tier system, a centralized system based at the proposed centre and Thomond College working year-round, if possible, but concentrating a great deal of its effort into short institutes held during holiday periods, especially the summer holiday period. This system is to be augmented by a decentralized system (but not uncoordinated) organized around centres where mathematical expertise is available locally e.g. teachers' centres, regional technical colleges and technological institutes and universities, and operating mainly during the school months. All such in-service activity should be subsidized by the Irish Department of Education but in the event that the Department is unable or unwilling to subsidize it, it should be *curtailed* but *not* discontinued and placed on an economical basis by requesting participants to pay fees which make each course a 'break-even' proposition. Such an eventuality would reduce the level of service drastically *but not to zero.* A major concern of such in-service course organizers must be the upgrading of mathematics teachers' qualifications in mathematical education [174]. It is important in this respect that teachers not only have an opportunity to attend conferences, seminars etc but also have the opportunity of adding to their *formal qualifications* by attending diploma or certificate courses in mathematical education. Such courses are now generally available in other countries such as the U.K. where the Diploma in Mathematical Education of the Mathematical Association and the Post-Graduate Certificate for Science and Mathematics teachers at Chelsea College are notable examples. *No such courses are available in Ireland.* The author concludes therefore that such a post-graduate course(s) should be initiated at the proposed centre and that it be developed to suit two different kinds of student intake: (1) serving mathematics teachers; and (2) graduates recruited to teach mathematics on the basis of mathematics in their primary degrees. The latter group of graduates, until such time as the Diploma in Mathematical Education is recognized per se, should be allowed to substitute it for the Higher Diploma in Education.

The five point plan outlined above offers a coherent framework for the development of mathematical education - a plan which can be implemented immediately for an annual extra outlay of approximately thirty thousand pounds. In summary the points are:

1. designate mathematics a special subject and thereby open Thomond College of Education to all students

2. augment facilities in mathematical education at Thomond College to prepare ab initio an annual intake of 15-20 specially selected students

3. create a centre for the improvement of instruction in mathematics with a permanent director and four other expert staff members. (This includes facilities mentioned in 2.)

4. create a coherent plan for in-service education of mathematics teachers in Irish secondary schools.

5. require all new entrants to secondary mathematics teaching to take

the Diploma in Mathematical Education prior to service in schools.

The existence of a research unit such as the centre for the improvement of instruction in mathematics would guarantee an active research commitment in mathematical education in Ireland. *Such a development would be very desirable and must be seen as a necessary, although not sufficient, prerequisite for an improved mathematics education for Irish children and their teachers.*

3. Further Recommendations

Because of the nature and organization of the educational provision in Ireland - already treated at length by the author in chapters II, III, IV, and V - no plan however significant or important for Irish education can succeed without the active support of the central authority in education, namely, the Irish Department of Education. This government department has been content for the most part to administer and control education by various supervisory means and has been loath to assume a posture of leadership in education in Ireland. The system of secondary education perpetuated by this authority has several undesirable features for which, in the author's opinion, the Irish Department of Education must accept responsibility. The author has singled out those features which in his view affect mathematical education in Ireland. This list is presented as a backdrop against which the author's recommendations are made and it is hoped thereby to make the recommendations more intelligible. The undesirable features are:

1. the extreme centralization of the school system under the Irish Department of Education. Department enforced national standards

effectively 'level-down' school performance.

2. the extreme denominationalism of the school system. The Irish Department of Education abdicated its responsibility in education for many years in favour of the Catholic Church in Ireland. The 'other worldly' goals of Catholic education contributed to an extreme classical bias in secondary education which operated to the detriment of science and mathematics.

3. the role of parents in Irish education has been usurped by the Catholic Church and the Irish Department of Education .

4. Irish secondary education has not been responsive to the needs of Irish pupils and society generally.

5. the secondary school curriculum is examinations - oriented with consequential bad effects on teaching.

6. the secondary school curriculum is university-oriented even now when only approximately 13 per cent of pupils in Ireland go on to higher education.

7. teachers generally have not been accorded professional standing by the Irish Department of Education and school authorities. This means that the professional needs of teachers e.g. initial and continuing education and training, have been neglected.

8. The Irish Department of Education has been reluctant to initiate, pursue or support research into the system of education on a continuing basis.

Obviously there is much that the Irish Department of Education can do to foster, improve and support mathematical education in Ireland. The author wishes to make the following specific recommendations.

The Irish Department of Education must:

1. adopt a more positive role in mathematical education by providing leadership in the field.

2. take all the necessary steps such as re-educating existing qualified personnel for their new role and inducting new expert personnel into their ranks.

3. fund research on mathematical education in Ireland on a continuing basis and give serious consideration to such research with a view to improving mathematical education in Ireland.

4. recognize and acknowledge the importance for Ireland and mathematical education in Ireland of a CAMET-type centre and support such a centre positively by providing resources.

5. actively promote professionalism in the teaching force by insisting on adequate standards and qualifications for all mathematics teachers and provide the resources for appropriate initial and continuing education of such teachers. This must include an annual allocation of funds for courses, conferences, seminars etc and a scheme for secondment and leave of absence.

6. institute an incentive scheme to attract mathematics graduates into the secondary school system. Such a scheme must include full salary during an initial period of pedagogical training.

7. break the stranglehold of the Irish universities on the mathematics curriculum at secondary level. This could be accomplished by:

   (i) consulting and giving weight to the voice of Industry and Commerce when mathematics syllabuses are being devised

   (ii) no longer coordinating mathematics in the Leaving Certificate Examination and course with university matriculation examinations.

8. initiate a re-examination of the secondary mathematics syllabus with a view to modifying it to meet the needs

of the majority of pupils i.e. those who do not go on to university. In this context attention must be given to those who leave school at 15.

9. decentralize the system of national extern examinations now in force and replace it with regional examinations boards.

The universities, too, have a part to play in mathematical education in Ireland. Their involvement must be directed less towards their own self-interests and more towards improving mathematical education. In this regard the author recommends that the Irish universities:

1. devote attention and resources to mathematical education as a university discipline and research area

2. appoint Professors of Mathematical Education

3. become more involved in in-service education for mathematics teachers by providing additional courses such as appropriate Diploma, or Degree courses in mathematical education.

4. become directly involved with schools and school mathematics teaching by instituting formal liaison with individual schools or groups of schools.

Other interests can contribute positively towards better mathematical education in Ireland. A major impediment to improving education, mathematical education in particular, is the lack of systematic research in that area. Research, as is generally known, flourishes when a proper attitude and spirit is allied with a keen sense of urgency, and resources are made available. Many of the author's recommendations are directed towards providing a climate for research, the need for and urgency of such research in the Irish context having already been highlighted. Since the bulk of the central authority's funds are allocated to maintaining the system at present levels little or nothing is left for research and development. Obviously the Irish Department of Education will have to do something to improve matters but other parties too must contribute. Here the author is thinking of industrial and commercial interests who are consumers of education but do little, apart from paying taxes and wages to support education. *The author proposes that resources for research in mathematical education be sought not only from the Irish Department of Education but also from industrial and commercial interests.*

4. <u>Further Research</u>

As is the case generally, proposed solutions raise new questions, new questions which cannot be answered in terms of the research already conducted. However, it is important to formulate the questions in order to indicate directions for future research. The cultural approach to mathematics, for example, is based on certain defensible points as already indicated, however, the cultural analysis is derived from a limited number of sources. It is almost certainly true that more research is needed to obtain a more comprehensive analysis of the cultural nature of mathematics and its implications for a cultural-map curriculum. Is the curriculum based on maps so devised comprehensive enough to meet the needs of future mathematics teachers? Does such a curriculum indeed facilitate and promote transfer of learning? Does the cultural approach and its associated ideological thinking contribute to a better educational experience for student-teachers? Such an approach which includes foundational studies in mathematics is obviously less economical than Bruner's structural approach to mathematics and its obvious reliance on the history of mathematics is directly counter to his notions on the primacy of the axiomatic method in mathematics [ ]. Is the teaching of the dynamic structure of mathematics, assuming that it can be taught effectively, more appropriate though obviously less economical for motivating students, and does it lead to mastery? It is obvious that research is needed into ways of teaching the cultural-map curriculum in mathematics. For example, does the pedagogical representation devised in this thesis really contribute to better student learning in mathematics? There is some evidence to support the claim that it does. Fuller [175] (p.172) has this to say:

> It is suggested that when a curriculum is designed about a modelling approach to learning, then it gets at the very heart of the problems of motivation and relevance.

A great deal of work is necessary before a satisfactory mathematics curriculum based on modelling and incorporating the features of the cultural analysis can be devised. Such an approach depends on discovering an effective means of teaching modelling. McDonald [176] has something to offer here on the specific theme of teaching modelling to undergraduate students. Studies of this type can be augmented by using existing courses based on mathematical modelling as exemplars. One such course is the M.Sc programme in Mathematical Education at the Polytechnic of the South Bank[1]. The Open University [177] Course "Modelling by Mathematics" is another important exemplar.

It is obvious that a cultural approach to mathematics based on models and modelling has implications for the mathematical education of school

---

1. Described to the author in private correspondence with Mr Oke who kindly supplied some course literature.

children. If the approach is viable at College level and this can only be determined by mounting a full-scale programme along the lines outlined, then some implications follow for other levels. It is suggested that such an approach:

(1) offers a coherent framework for a unified approach to mathematics teaching in primary, secondary schools and colleges of education;

(2) presents a means of dealing meaningfully with a standard syllabus;

(3) provides motivation and increases the relevance of education.

Such claims need to be subjected to scrutiny and future research.

In conclusion, it must be added that the questions raised above which derive from the research already completed, are considered sufficiently important in the context of mathematical education in Ireland to warrant further attention. They will be pursued by the author at Thomond College over the next few years.

APPENDIX A

MATHEMATICS SYLLABUSES FOR IRISH SECONDARY SCHOOLS[1]

1. Source: The Rules and Programmes for Secondary Schools of the Irish Department of Education. These are the only recognized mathematics syllabuses for Irish secondary schools.

MATHEMATICS

Preamble

The new syllabuses were originally introduced on the understanding that they would be revised from time to time. The present revised syllabuses in Mathematics for the Intermediate Certificate have resulted from such a review and have evolved after much discussion and consultation. The objectives of the syllabuses are that a student should:

— acquire skill in computing with understanding, accuracy and efficiency;

— acquire an understanding of Mathematical facts and concepts;

— understand the logical structure of Mathematics and the nature of a proof;

— use Mathematical concepts and processes to discover generalisations and applications;

— associate Mathematics with applications from everyday life;

— develop attitudes that lead to appreciation, confidence, initiative and independence;

— develop study habits, reading skill and vocabulary essential for independent progress in Mathematics.

To effectively achieve these objectives the teaching should be resourceful, inventive and creative and should examine the students' environment for the experiences, examples and analogies required to permit the formulation, enrichment and refinement of the fundamental concepts. Ultimately the students should be able to marshall their knowledge so that they could apply it to solve problems.

(Note 1: Each syllabus is divided for the convenience of teaching into three sections. The content of each section approximates to one year's work.

Note 2: Section One is common to both the Lower Course and Higher Course.

Note 3: It is recommended that reference be made where appropriate to the history of Mathematics and to the lives of great mathematicians.)

LOWER COURSE

Section One

Sets: Listing of elements of sets. Membership of a set defined by a rule. Subsets, Universe, Null (empty) set. Equality of sets. Venn diagrams. Set operations for two sets. Intersection. Union. Commutative property.

Relations: Couples (ordered pairs). Use of arrow diagrams.

Natural Numbers: Sets of numbers. N, N_0. Sets of divisors. Common divisors. Highest common divisor. Recognition of prime numbers.

Pairs of factors. Sets of multiples. Lowest common multiple. Cardinal number of a set. Addition of numbers in N. Commutative property. Numbers and numerals. Place value idea. Meaning of a^n when a, n $\in N_0$.

Bases: Numbers in bases other than denary. Counting in various bases. Interbase conversion to and from base 10. Addition in various bases.

Integers: Set of integers (Z). Order ($<, \leqslant, >, \geqslant$). Addition, subtraction, multiplication and division in the set of integers. Use of arrow diagrams to illustrate order relations and the relations

$$+ a, \quad - a, \quad \times a, \quad \text{for } a \in Z$$

Rational Numbers: Set of rational numbers (Q). Decimals, Fractions, Ratio. Positional order on number line for fractions and decimals. Non-zero positive rationals expressed in the form $a.10^n$, where $n \in Z$ and $1 \leqslant a < 10$.

Computation: Addition, subtraction, multiplication and division of decimals and fractions.

Measure: SI units. Basic units of length, mass and time. Multiples and sub-multiples. Speed. Area (square, rectangle). Volume (rectangular solids). Proportion, percentage. Profit and loss. Percentage discount. Percentage profit. Bills. Rates. Tax. Annual interest.

Algebraic Expressions: Idea of a place holder and variable. Addition and subtraction of simple algebraic expressions such as

$$(2x + 3) + (4x - 2); (3x + 2y) - (x + 3y - 4),$$
$$(5x^2 + 7x - 2) + (2x^2 - x - 7).$$

Equations: Formation and interpretation of number sentences. Solution set of simple first degree equations in one variable. Graphing of solution set on the number line.

Inequalities: First degree inequalities in one variable in N, Z, Q.

Pattern: Recognition of pattern in simple numerical sequences. Writing down of specific terms of a sequence given the general term.

The Plane Π: The plane Π is an infinite set of points. .... **Axiom 1**
Simple intuitive ideas of such subsets of Π as: arcs, closed curves; simple closed curves, inside, outside.
Between any two points of an arc there is another point of the arc .... **Axiom 2**

Intersection of arcs. Subsets of Π: intersection, union.

Line: A line is an infinite proper subset of Π. .... **Axiom 3**
Every pair of distinct points is contained in one and only one line.
.... **Axiom 4**

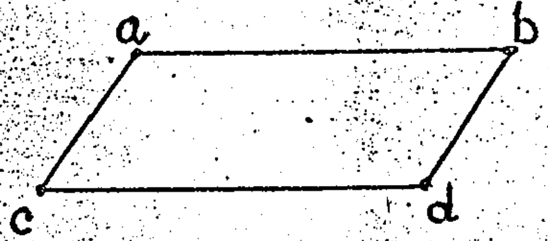
The line containing the points a and b may be denoted by ab.
The line segment with end points a and b is denoted by [a b].

Parallel Lines: Two lines A and B are parallel if, and only if, A intersection B $= \varnothing$ or A = B. .... **Definition 1**

Given a line L and a point p, there is one and only one line parallel to L which contains p. .... **Axiom 5**

Construction: Using set square and ruler, construct through a point a line parallel to a given line.

Parallelograms: abdc is a parallelogram if and only if ab||cd and ac||bd, where a, b, c, d are not collinear.



.... **Definition 2**

Equipollent Couples

Non-Collinear Couples: (a, b) is equipollent to (c, d) if and only if abdc is a parallelogram.

Collinear Couples: (a, b) is equipollent to (c, d) if and only if there is a couple (x, y) not collinear with (a, b) such that (a, b) is equipollent to (x, y) and (x, y) is equipollent to (c, d).

Identity Couples: (a, a) is equipollent to (b, b)
.... **Definition 3**

Notation: (a, b) equipollent to (c, d) is denoted by $(a, b) \uparrow (c, d)$.

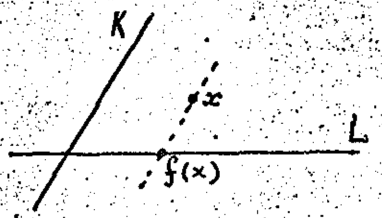
Corollary 1. $(a, b) \uparrow (c, d) \Rightarrow (b, a) \uparrow (d, c)$.

Corollary 2. For non-collinear couples
$(a, b) \uparrow (c, d) \Rightarrow (a, c) \uparrow (b, d)$.

Transitivity of Equipollence:

$$\begin{matrix} (a, b) \uparrow (c, d) \\ \text{and} \\ (c, d) \uparrow (e, f) \end{matrix} \Rightarrow (a, b) \uparrow (e, f)$$ .... **Axiom 6**

Parallel Projection of Π:
f(x) is the image of x by the projection on L parallel to K.



.... **Definition 4**

Image of a set by a projection f: $x \to f(x)$.

Translation of Π: The translation $\overrightarrow{ab}$ is the set of all couples (c, d) such that (c, d) ↑ (a, b) .... **Definition 5**
Image of a set by a translation f: $x \to f(x)$.

Centre: c is the centre of a couple (a, b) if and only if (a, c) ↑ (c, b).
.... **Definition 6**

Central Symmetry of Π: The central symmetry S_c is the set of all couples such that c is the centre of each of them.
.... **Definition 7**

Image of a set by a central symmetry f: $x \to f(x)$.

Section Two

Sets: Set operations: difference, complement. Set operations extended to three sets. Associative property. Necessity of brackets for the non-associative operation of difference.

Relations and Functions: Domain and range. Function (map) as a special relation.

Rational Numbers: Rational numbers expressed as decimals. Terminating decimals expressed as fractions.

Real Numbers: Elementary concept of the real number system using the number line. Rational approximations for irrational numbers such as $\sqrt{2}$ and π for calculation purposes. Calculation to a specified degree of accuracy involving addition, subtraction, multiplication and division. Associative property of addition and of multiplication. Non-associativity of subtraction and of division. Distributive property of multiplication over addition. Non-distributivity of addition over multiplication. Inequalities in R.

Algebraic Expressions: Use of distributive property in the removal of brackets in such expressions as $3(x + 4) - 5(2x + 3) + 2(5x - 6)$. Multiplication of expressions such as $(2x - 3)(5x + 4)$, $(x - 4)(x^2 - 5x + 11)$ etc. Division of expressions such as $(2x^2 + 11x - 15) \div (x + 3)$, $(6x^2 + x - 12) \div (3x - 4)$, $(6x^3 - x^2 - 33x - 28) \div (3x + 4)$.

Factors: Use of the distributive law in the factorising of such expressions as: $6xy + 3y^2$, $ax - by + bx - ay$. Factors of quadratic expressions of the form $x^2 + bx + c$, where b, c are in Z.

Equations: Quadratic equations of the form $x^2 + px + q = 0$ where $x^2 + px + q$ is readily factorisable.

Statistics: Drawing and interpreting pictograms, bar-charts, pie-charts, trend graphs.

Tables: Use of formulas provided in the table book for length of circle and surface area of disc.

Logarithms: Use of logarithmic tables (or slide rule) in calculations not involving negative characteristics. Calculation of square root by use of tables or by an approximation method.

Direction: Direction as a set of parallel lines. .... **Definition 8**
To every direction there is one, and only one, direction perpendicular to it. .... **Axiom 7**

Construction: Use of set square to draw a perpendicular to a line through a point.

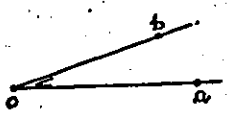
Axial Symmetry of Π (Reflection of Π in a line).
The axial symmetry S_L in a line L is the set of all couples (a, b) such that
(i) $ab \perp L$
(ii) centre of $(a, b) \in L$ .... **Definition 9**
Image of a set by an axial symmetry $f: x \rightarrow f(x)$.

Rotation of Π: The axial symmetry in an axis A followed by the axial symmetry in an axis B, where A and B are not disjoint, defines the rotation $S_B \circ S_A$. .... **Definition 10**
Image of a set by a rotation $f: x \rightarrow f(x)$.

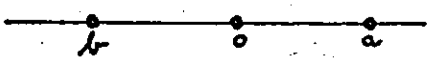
Angle: An angle is formed by two half-lines [oa and [ob and is called $\angle aob$ or $\angle boa$.

Measure of an angle in degrees.

Measure of $\angle aob$ is written as $|\angle aob|$.

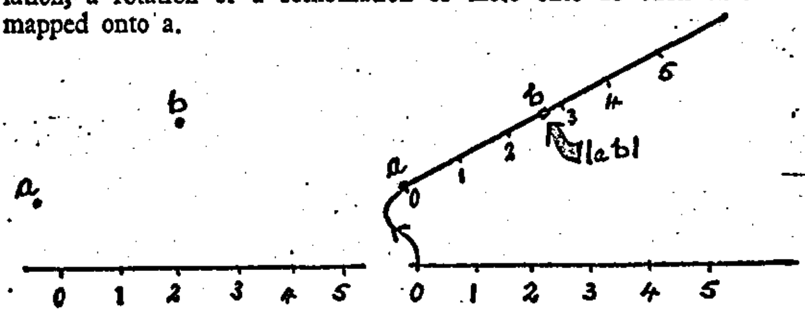


If [oa and [ob are collinear, thus



then $\angle aob$ is called a straight angle and $|\angle aob| = 180°$.

Distance:
The distance, $|a\ b|$, between two points a and b is the real number which is mapped onto b when the number line is mapped by a translation, a rotation or a combination of these onto ab such that 0 is mapped onto a.



Translation, central symmetry and axial symmetry conserve length, area and measure of angle. .... Axiom 8
Parallel projection conserves equipollence (no proof required).

Construction: Midpoint of [ab] is centre of (a, b).
Bisect a given line segment.

Section Three

Relations and Functions: Coordinating the plane. Drawing graphs of functions f: $x \rightarrow f(x)$, where $f(x)$ is of the forms $3x + 4$, $x^2 - 5x + 6$.

Equations: First degree equations in two variables. Problems, solutions and graphical treatment.

Compound Interest: Calculation of compound interest — interest added annually for up to 3 years (formula not required).

Tables: Use of formulae provided in the table book for surface area and volume of cylinder and sphere.

Statistics: Expression of discrete array as a frequency table. Mean and mode.

Algebraic Expressions: Addition and subtraction of algebraic expressions such as

$$\frac{a}{bx + c} \pm \frac{p}{qx + r}, \text{ where } a, b, c, p, q, r \in Z.$$

Quadratic Functions: Graphical illustration of quadratic functions.

Factors: Factors of quadratic expressions of the form $ax^2 + bx + c$ where "a" is a prime number. Factorisation of the difference of the two squares.

Equations: Quadratic equations in one variable (rational roots only). Use of formula acceptable but not essential. Simple problems leading to quadratic equations.

Trigonometry: Cosine, sine and tangent of angles. Reading trigonometrical tables. Solving right angled triangle problems of a simple nature in heights and distances with the aid of trigonometry. (Theorem of Pythagoras may be assumed.)

(Proofs of theorems are to be based on the content of the syllabus.)

Theorem 3.1 Diagonals of a parallelogram bisect each other. (Converse may be assumed to be true.)

Theorem 3.2 Translation maps a line onto a parallel line.

Theorem 3.3 Central symmetry maps a line onto a parallel line.

Theorem 3.4 When a transversal cuts two parallel lines, then
(a) corresponding angles are equal in measure;
(b) alternate angles are equal in measure.
(Converse may be assumed to be true.)

Theorem 3.5 The sum of the measures of the three angles of a triangle is 180°.

Theorem 3.6 The measure of the exterior angle of a triangle equals the sum of the measures of the two interior opposite angles.

If [oa and [ob are two half lines, then there is one, and only one, line M such that S_M maps [oa on [ob. .... **Axiom 9**

M is called the bisector of ∠aob.

Theorem 3.7 If two sides of a triangle are equal in length, then the measure of the angles opposite these sides are also equal. (Converse may be assumed to be true.)

Construction Bisect a given angle.

The distance of a point x from a line L is |xa|, where xa ⊥ L and a ε L. .... **Definition 11**

The area of a parallelogram abcd is |ab| .h, where h is the distance of c from ab. .... **Definition 12**

Theorem 3.8 A diagonal of a parallelogram bisects the area of the parallelogram.

Theorem 3.9 The area of a triangle abc is $\frac{1}{2}$ |ab| .h, where h is the distance of c from ab.

Theorem 3.10 If x ε M, the perpendicular bisector (mediator) of a line segment [ab], then |xa| = |xb|. (Converse may be assumed to be true.)

Definition of Circle K: K = {x | |xc| = r, c ε Π, r ε R}, where c is a fixed point and r a fixed number, c is the centre of K and r is the length of a radius of K. .... **Definition 13**

Construction Construct, with proof, the circumcircle of a triangle.

Theorem 3.11 Any point of the bisector of ∠aob is equidistant from oa and ob. (Converse may be assumed to be true.)

Theorem 3.12 A circle is mapped onto itself by the axial symmetry in any line through its centre.

Theorem 3.13 The diameter of a circle which is perpendicular to a chord of the circle bisects the chord.

A line L is tangent to a circle K at the point t if L intersection K = {t}. .... **Definition 14**

Theorem 3.14 The diameter of a circle which is perpendicular to a tangent contains the point of contact. (Converse may be assumed to be true.)

Construction Construct, with proof, the incircle of a triangle.

Theorem 3.15 The angle at a point of a circle standing on a diameter is a right angle. (Converse may be assumed to be true.)

Construction Construct, with proof, a tangent to a circle through a point (i) belonging to the circle, (ii) outside the circle.

HIGHER COURSE

Section One

Sets: Listing of elements of sets. Membership of a set defined by a rule. Subsets, Universe, Null (empty) set. Equality of sets. Venn diagrams. Set operations for two sets. Intersection. Union. Commutative property.

Relations: Couples (ordered pairs). Use of arrow diagrams.

Natural Numbers: Sets of numbers. N, N_o. Sets of divisors. Common divisors. Highest common divisor. Recognition of prime numbers. Pairs of factors. Sets of multiples. Lowest common multiple. Cardinal number of a set. Addition of numbers in N. Commutative property. Numbers and numerals. Place value idea. Meaning of a^n when $a, n \in N_o$.

Bases: Numbers in bases other than denary. Counting in various bases. Interbase conversion to and from base 10. Addition in various bases.

Integers: Set of integers (Z). Order ($<, \leqslant, >, \geqslant$). Addition, subtraction, multiplication and division in the set of integers. Use of arrow diagrams to illustrate order relations and the relations

$$+a, -a, \times a, \text{ for } a \in Z.$$

Rational Numbers: Set of rational numbers (Q). Decimals, Fractions, Ratio. Positional order on number line for fractions and decimals. Non-zero positive rationals expressed in the form $a.10^n$, where $n \in Z$ and $1 \leqslant a < 10$.

Computation: Addition, subtraction, multiplication and division of decimals and fractions.

Measure: SI units. Basic units of length, mass and time. Multiples and sub-multiples. Speed. Area (square, rectangle). Volume (rectangular solids). Proportion, percentage. Profit and loss. Percentage discount. Percentage profit. Bills. Rates. Tax. Annual interest.

Algebraic Expressions: Idea of a place holder and variable. Addition and subtraction of simple algebraic expressions such as

$$(2x + 3) + (4x - 2), (3x + 2y + 7) - (x + 3y - 4),$$
$$(5x^2 + 7x - 2) + (2x^2 - x - 7).$$

Equations: Formation and interpretation of number sentences. Solution set of simple first degree equations in one variable. Graphing of solution set on the number line.

Inequalities: First degree inequalities in one variable in N, Z, Q.

Pattern: Recognition of pattern in simple numerical sequences. Writing down of specific terms of a sequence given the general term.

The Plane Π: The plane Π is an infinite set of points .... **Axiom 1**
Simple intuitive ideas of such subsets of Π as: arcs, closed curves; simple closed curves, inside, outside.

Between any two points of an arc there is another point of the arc .... **Axiom 2**

Intersection of arcs. Subsets of Π: intersection, union.

Line: A line is an infinite proper subset of Π .... **Axiom 3**
Every pair of distinct points is contained in one and only one line. .... **Axiom 4**

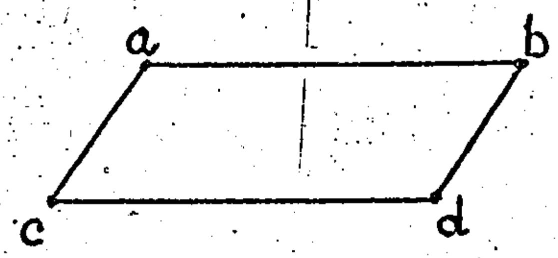
The line containing the points a and b may be denoted by ab.
The line segment with end points a and b is denoted by [a b].

Parallel Lines: Two lines A and B are parallel if, and only if, A intersection B = ∅ or A = B. .... **Definition 1**

Given a line L and a point p, there is one and only one line parallel to L which contains p. .... **Axiom 5**

Construction: Using set square and ruler, construct through a point a line parallel to a given line.

Parallelograms: abdc is a parallelogram if and only if ab||cd and ac||bd, where a, b, c, d are not collinear.



.... **Definition 2**

Equipollent Couples

Non-Collinear Couples: (a, b) is equipollent to (c, d) if and only if abdc is a parallelogram.

Collinear Couples: (a, b) is equipollent to (c, d) if and only if there is a couple (x, y) not collinear with (a, b) such that (a, b) is equipollent to (x, y) and (x, y) is equipollent to (c, d).

Identity Couples: (a, a) is equipollent to (b, b) .... **Definition 3**

Notation: (a, b) equipollent to (c, d) is denoted by (a, b) ↑ (c, d).

Corollary 1. (a, b) ↑ (c, d) ⟹ (b, a) ↑ (d, c).

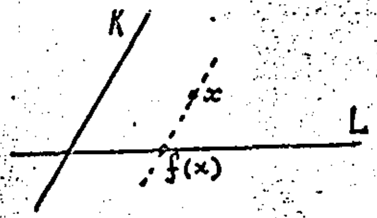
Corollary 2. For non-collinear couples
(a, b) ↑ (c, d) ⟹ (a, c) ↑ (b, d).

Transitivity of Equipollence:

$$\left.\begin{array}{c}(a, b) \uparrow (c, d) \\ \text{and} \\ (c, d) \uparrow (e, f)\end{array}\right\} \Rightarrow (a, b) \uparrow (e, f) \qquad \text{......... Axiom 6}$$

Parallel Projection of Π:

f(x) is the image of x by the parallel projection on L parallel to K.



.... **Definition 4**

Image of a set by a projection $f{:}x \rightarrow f(x)$.

Translation of Π: The translation $\overrightarrow{ab}$ is the set of all couples (c, d) such that $(c, d) \uparrow (a, b)$ .... **Definition 5**
Image of a set by a translation $f\colon x \rightarrow f(x)$.

Centre: c is the centre of a couple (a, b) if and only if $(a, c) \uparrow (c, b)$.
.... **Definition 6**

Central Symmetry of Π: The central symmetry S_c is the set of all couples such that c is the centre of each of them.
.... **Definition 7**
Image of a set by a central symmetry $f\colon x \rightarrow f(x)$.

Section Two

Sets: Set operations; difference, complement, symmetric difference. Set operations extended to three sets. Associative property. Necessity of brackets for the non-associative operation of difference. Cardinal number. Closure of a set under an operation.

Relations and Functions: Cartesian product of two sets. Domain and range. The reflexive, symmetric and transitive properties of such simple relations as equality, parallelism etc. Function (map) as a special relation. Notion of inverse of a function. Composition of functions. Coordinating the plane. Drawing graphs of functions $f\colon x \rightarrow f(x)$, where $f(x)$ is of the form $3x + 4$, $x^2 - 5x + 6$.

Equations: First degree equations in two variables. Problems, solutions and graphical treatment.

Rational Numbers: Rational numbers expressed as decimals. Terminating decimals expressed as fractions. Illustration of the fact that a non-terminating repeating decimal is rational.

Real Numbers: Elementary concept of the real number system using the number line. Rational approximations for irrational numbers such as $\sqrt{2}$ and π for calculation purposes. Calculation to a specified degree of accuracy involving addition, subtraction, multiplication and division.

Addition is associative and commutative. Multiplication is associative and commutative. Non-associativity of subtraction and of division. Non-distributivity of addition over multiplication. Inequalites in R.

Numerical Calculations: Calculation of compound interest — interest to be added annually for up to three years (formula not required). Use of mathematics tables (or slide rule) in calculations. Square root by mathematics tables or by approximation method. Use of formulae provided in mathematics tables for length of circle; area of disc, surface area of cylinder, cone and sphere; volume of cylinder, cone and sphere.

Trigonometry: Cosine, sine and tangent of angles. Values of these functions for 0°, 30°, 45°, 60°, 90°, 180°, 270°, 360°, where defined.

Algebraic Expressions: Use of distributive property in the removal of brackets. Multiplication and division of expressions including the expansion of $(x + y)^2$, $(x - y)^2$, $(x + y)^3$, $(x - y)^3$.

Factors: Use of distributive law in the factorising of such expressions as $6xy + 3y^2$, $ax - by + bx - ay$. Factors of expressions of the form $ax^2 + bx + c$. Factors of such expressions as $x^2 - 4y^2$, $x^3 - y^3$, $x^3 + y^3$.

Equations: Quadratic equations of the form $ax^2 + bx + c = 0$, where $ax^2 + bx + c$ is factorisable.

Statistics: Drawing and interpreting pictograms, bar-charts, pie-charts, trend graphs. Moving averages.

Direction: Direction as a set of parallel lines. .... **Definition 8**
To every direction there is one and only one direction perpendicular to it. .... **Axiom 7**

Deduction from axiom 7:
(for example) $A \perp B \parallel C \Rightarrow A \perp C$; $A \perp B \perp C \Rightarrow A \parallel C$;

Construction: Use of set square to draw a perpendicular to a line through a point.

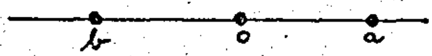
Axial Symmetry of Π (Reflection of Π in a line):
The axial symmetry S_L in a line L is the set of all couples (a, b) such that
(i) $ab \perp L$
(ii) Centre of (a b) $\in L$ .... **Definition 9**
Image of a set by an axial symmetry $f: x \to f(x)$.
Composition of two or more axial symmetries.

Rotation of Π: The axial symmetry in an axis A followed by the axial symmetry in an axis B, where A and B are not disjoint, defines the rotation $S_B \circ S_A$. .... **Definition 10**
Image of a set by a rotation $f: x \to f(x)$.

Angle: An angle is formed by two half-lines [oa and [ob and is called $\angle aob$ or $\angle boa$.
Measure of an angle in degrees.

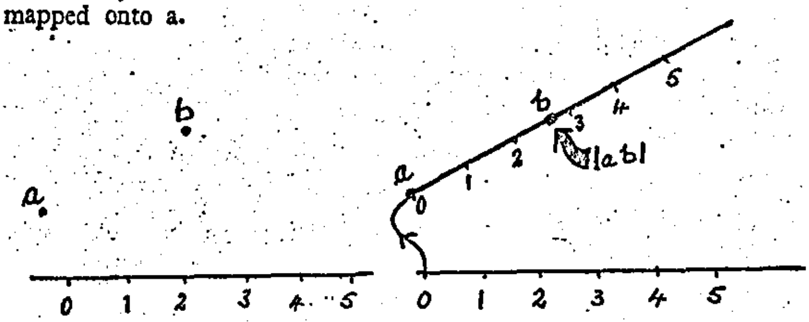
Measure of $\angle aob$ is written $|\angle aob|$.

If [oa and [ob are collinear, thus



then $\angle aob$ is called a straight angle and $|\angle aob| = 180°$.

Distance: The distance, $|ab|$, between two points a and b, is the real number which is mapped onto b when the number line is mapped by a translation, a rotation or a combination of these onto ab such that 0 is mapped onto a.



Isometry of Π: Translation, central symmetry and axial symmetry conserve length, area and measure of angle. .... Axiom 8
(Proofs of theorems are to be based on the content of the syllabus.)

Theorem 2.1 Parallel projection conserves equipollence.

Construction Midpoint of [ab] is centre of (a, b).
Bisect a given line segment.

Theorem 2.2 For collinear couples
$(a, b) \uparrow (c, d) \Rightarrow (a, c) \uparrow (b, d)$.

Theorem 2.3 The composition of two translations is a translation.
(Note: The composition of $\vec{ab}$ and $\vec{ab}$ is written as $2\,\vec{ab}$.)

Theorem 2.4 The composition of two central symmetries is a translation.

Theorem 2.5 The composition of two axial symmetries in perpendicular axes is a central symmetry.

Theorem 2.6 The composition of two axial symmetries in parallel axes is a translation.

Section Three

Functions: Maximum or minimum value of a quadratic function found graphically. Solution of a quadratic inequality found from the graph of a quadratic function.

Equations: Quadratic equations of the form $ax^2 + bx + c = 0$ — real roots only.

Algebraic Expressions: Addition and subtraction of algebraic expressions such as

$$\frac{a}{bx + c} \pm \frac{p}{qx + r}, \text{ where } a, b, c, p, q, r \in Z.$$

Indices and Logarithms: $\log_c a = x \Rightarrow a = c^x$. Justification of

(i) $\log_c ab = \log_c a + \log_c b$. (ii) $\log_c \frac{a}{b} = \log_c a - \log_c b$

(iii) $\log_c a^p = p \log_c a$ (iv) $\log_c a = \frac{\log_{10} a}{\log_{10} c}$.

Numerical applications.

Trigonometry: Reading trigonometrical tables. Solving right angled triangle problems of a simple nature (e.g. height and distance). Area of triangle. Sine rule with applications.

Coordinate Geometry: Coordinates of the images of points by projection, translation, central symmetry and axial symmetry. Distance. Midpoint. Slope of line. Area of triangle.

Equation of line in the forms $y = mx + c$ and $y - y_1 = m(x - x_1)$. Intersection of lines. Equation of the image of a line by a translation. Equation of the image of a line $y = mx$ by the rotation $S_Y \circ S_L$, where Y is the y-axis and L is the line $y = x$, is $y = -\frac{1}{m}x$.

Statistics: Expression of a discrete array as a frequency table. Mean and mode.

(Proofs of theorems are to be based on the content of the syllabus.)

Theorem 3.1 Diagonals of a parallelogram bisect each other. (Converse may be assumed to be true.)

Theorem 3.2 Translation maps a line onto a parallel line.

Theorem 3.3 Central symmetry maps a line onto a parallel line.

Theorem 3.4 When a transversal cuts two parallel lines, then
(a) corresponding angles are equal in measure;
(b) alternate angles are equal in measure.
(Converse may be assumed to be true.)

Theorem 3.5 The sum of the measures of the three angles of a triangle is 180°.

Theorem 3.6 The measure of the exterior angle of a triangle equals the sum of the measures of the two interior opposite angles.
If [oa and [ob are two half lines, then there is

one, and only one, line M such that S_M maps [oa on [ob. .... **Axiom 9**

M is called the bisector of ∠aob.

Theorem 3.7 If two sides of a triangle are equal in length, then the measures of the angles opposite these sides are also equal (Converse may be assumed to be true.)

Construction Bisect a given angle.

The distance of a point x from a line L is |xa|, where xa ⊥ L and a ε L. .... **Definition 11**

The area of a parallelogram abcd is |ab| .h, where h is the distance of c from ab. .... **Definition 12**

Theorem 3.8 A diagonal of a parallelogram bisects the area of the parallelogram.

Theorem 3.9 The area of a triangle abc is ½ |ab| .h, where h is the distance of c from ab.

Theorem 3.10 If x ε M, the perpendicular bisector (mediator) of a line segment [ab], then |xa| = |xb|. (Converse may be assumed to be true.)

Definition of Circle K: K = {x | |xc| = r, c ε Π, r ε R}, where c is a fixed point and r a fixed number, c is the centre of K and r is the length of a radius of K. .... **Definition 13**

Construction Construct with proof the circumcircle of a triangle.

Theorem 3.11 Any point of the bisector of ∠aob is equidistant from oa and ob. (Converse may be assumed to be true.)

Theorem 3.12 A circle is mapped onto itself by the axial symmetry in any line through its centre.

Theorem 3.13 The diameter of a circle which is perpendicular to a chord of the circle bisects the chord.

A line L is tangent to a circle K at the point t if L intersection K = {t}. .... **Definition 14**

Theorem 3.14 The diameter of a circle which is perpendicular to a tangent contains the point of contact. (Converse may be assumed to be true.)

Construction Construct, with proof, the incircle of a triangle.

Theorem 3.15 The measure of the angle at the centre of a circle is twice the measure of an angle at the circle standing on the same arc.

Deduction 1 All the angles at the circle standing on the same arc are equal in measure.

Deduction 2 An angle at the circle standing on a diameter is a right angle. (Converse may be assumed to be true.)

Construction	Construct, with proof, a tangent to a circle through a point (i) belonging to the circle, (ii) outside the circle.
Theorem 3.16	The perpendicular bisectors of the sides of a triangle are concurrent.
Theorem 3.17	The bisectors of the interior angles of a triangle are concurrent.
Theorem 3.18	The areas of two triangles of equal height are proportional to the lengths of their bases.
Theorem 3.19	Two sides of a triangle are divided proportionally by a line drawn parallel to the third side. (Converse may be assumed to be true.)
Theorem 3.20	If the angles of two triangles are equal in measure, then the lengths of their corresponding sides are proportional. (Converse may be assumed to be true.)
Theorem 3.21	[ab] and [cd] are two chords of a circle. If the lines ab and cd intersect at k, then $\lvert ak\rvert \cdot \lvert kb\rvert = \lvert ck\rvert \cdot \lvert kd\rvert$.
Deduction	From a point p outside a circle a tangent is drawn to touch the circle at t and a line is drawn to cut the circle at a and b, then $\lvert pa\rvert \cdot \lvert pb\rvert = \lvert pt\rvert^2$. (Converse may be assumed to be true.)
Theorem 3.22	Theorem of Pythagoras. (Converse may be assumed to be true.)

LEAVING CERTIFICATE PROGRAMME

MATHEMATICS

(for examination in 1978 and in future years)

Preamble.

The present revised syllabus endeavours to combine in one unified structure topics which are traditional with those which are modern and relevant. Appropriate emphasis is placed on the logical steps which guide students in making decisions and vadid judgments and due consideration is given to the fact that Mathematics in an ever-expanding open-ended subject. Although the sole justification for the inclusion of Mathematics in the curriculum is not the use that is made of it outside school, however the many varied and interesting applications constitute a powerful motivation which is an important factor in the natural process of learning.

In presenting this syllabus to students, the teacher's objectives should be:

- to develop conceptual and meaningful Mathematics together with efficent computational skills;
- to emphasise key concepts and fundamental structures;
- to present Mathematics as an ever-expanding open-ended subject;
- to show Mathematics both as an abstract, autonomous body of knowledge as well as a useful, operational tool;
- to encourage active involvement in enquiry-oriented learning;
- to develop an understanding of elementary statistics and of numerical methods;
- to coordinate with other subjects;
- to enable students to attain knowledge and insight by means of classroom and independent study;
- to prepare students for further study in Mathematics;
- to encourage logical thinking.

In achieving these objectives teachers should endeavour to interest pupils in the subject, to develop in them a love of Mathematics and an appreciation of its method, power and elegance.

Accuracy, neatness of presentation and logical lay-out of solutions should receive sufficient attention as should skill in the use of instruments in geometrical constructions and in the sketching of diagrams and graphs.

ORDINARY LEVEL

Mensuration: Regular areas and solids including cone.

Statistics: Elementary idea of frequency and cumulative frequency distributions. Graphical treatment. Median. Simple treatment of standard deviation given an array of numbers or a frequency distribution, including grouped frequencies. (Use of assumed mean not required). Weighted averages.

Equations: Solution of quadratic equations and of cubic equations with at least one integral root. Linear equations in two and in three unknowns, including sets of equations in two unknowns having non-unique solutions. Equations of the form.

$$\frac{3}{3x-2} - \frac{1}{2x+3} = 2 - \frac{x+1}{6x^2+5x-6}$$

Manipulation of formulae.

Factors: Cubic expressions of the form $a^3 + b^3$, $8x^3 - 27$. Use of remainder theorem.

Indices and Logarithms: Use of logarithmic tables (or slide rule) in calculations. (Proofs of formulae not required)

Sequences and Series: Arithmetic and geometric. Derivation of formulae. Summation. Applications to include compound interest formula. Sum of infinite geometric series as the $\lim_{n\to\infty} S_n$.

Relations: Examples of order relations.

Functions: Domain, codomain, range. Bijections, inverse functions, composition of functions.

Graphs: Quadratic and cubic functions. Interpretation as regards changes of value and sign.

Inequalities: Quadratic inequalities in one variable. Linear inequalities in two variables and elementary linear programming limited to two lines and two lines parallel to the axes.

Trigonometry: Radian measure of angles. Definitions of the trigonometric functions sine and cosine for all values of the independent variable. Graphs of sine and cosine to illustrate periodicity. Definition of the tangent function. Compound angle formulae (proofs not required). Simple identities. Area of triangle. Sine and cosine rules and their applications.

Complex Numbers: Addition, subtraction, multiplication and division. Representation by Argand diagram. Absolute value (modules).

Geometry

Concurrencies in a Triangle: Bisectors of angles, perpendicular bisectors of sides, medians, perpendiculars from vertices to opposite sides.

Theorem 5.1 The measure of the angle at the centre of a circle is twice the measure of an angle at the circle standing on the same arc.

Deduction All the angles at the circle standing on the same arc are equal in measure.

Theorem 5.2 Triangles on the same base and between the same parallels are equal in area.

Theorem 5.3 The areas of two triangles of equal height are proportional to the lengths of their bases.

Theorem 5.4 Two sides of a triangle are divided proportionally by a line drawn parallel to the third side.

Theorem 5.5 If the angles of two triangles are equal in measure, then the lengths of their corresponding sides are proportional.

Theorem 5.6 [ab] and [cd] are two chords of a circle. If the lines ab and cd intersect in k, then

$$|ak|.\,|kb| = |ck|.\,|kd|$$

(Internal and external cases)

Theorem 5.7 From a point p outside a circle a tangent is drawn to touch the circle at t and a line is drawn to cut the circle at a and b. Then

$$|pa|.|pb| = |pt|^2.$$

Theorem 5.8 In a right angled triangle the area of the square on the hypotenuse is equal to the sum of the areas of the squares on the other two sides. (Pythagoras).

(Note: The converse of each of the above theorems is true. Proof not required).

Analytical Geometry: Coordinates (including the image of a point by a parallel projection and by the isometries listed in the Intermediate Certificate syllabus). Distance between points. Area of triangle. Midpoint of line segment. Slope. Equation of line in the forms $y = mx + c$ and $y - y_1 = m(x - x_1)$. Line through two given points, lines parallel to and lines perpendicular to a given line and through a given point. Intersection of two lines. The equation $x^2 + y^2 = a^2$. Intersection of a line and a circle. Proving a line is a tangent to a circle. The equation of a circle in the form $(x - h)^2 + (y - k)^2 = a^2$.

Vectors: The composition of two translations is a translation. Vector $\vec{ab}$ represented as the translation $\vec{ab}$. Addition and subtraction of vectors. Multiplication of a vector by a scalar. The pointed plane. The perpendicular unit vectors $\vec{i}$, $\vec{j}$.

Binomial Theorem: Meaning of the symbols $n!$, $\binom{n}{r}$ The expansion of $(x + a)^n$ for $n \in N$. (Proof not required). Easy applications.

Calculus: Rate of change. Geometrical idea of a tangent line. Slope of tangent line defined as a limit. Definition of a derivative as a limit. Calculation of the derivative of polynomials of degree not exceeding three from first principles. Formulae for the derivative of x^n ($n \in N$), $u + v$, uv, $\frac{u}{v}$ and for the chain rule e.g. $(x^7 + 3)^5$, $(4x^2 - 3x + 1)^2$. (Proofs not required). Simple problems to include the application of the first derivative to drawing graphs of quadratic and of cubic functions. Local maximum and local minimum.

LEAVING CERTIFICATE PROGRAMME

HIGHER LEVEL

Complex Numbers: Need for complex numbers. Complex conjugate, modulus. Argand diagram. Meaning of $|z-a|$ for $a \in C$. Easy loci. Complex roots of $p(x) = 0$, where $p(x)$ is a polynomial with real coefficients. De Moivre's Theorem – proof by induction when $n \in N$. Applications when $n \in Q$.

$|z|^2 = z.\bar{z}$; $\quad |z_1 z_2| = |z_1|.|z_2|$;

$|z_1 + z_2| \leqslant |z_1| + |z_2|$; $\quad |z_1 - z_2| \geqslant |z_1| - |z_2|$.

Equations: Linear equations in two and in three variables including sets of equations having non-unique solutions. Remainder Theorem and its application to finding the roots of cubic equations. Approximate roots of cubic equations.

Binomial Theorem: Permutations and combinations. Proof by induction of binomial theorem when $n \in N$. Numerical applications when $n \in Q$.

Analytical Geometry (Line and Circle): Distance of a point from a line. Angle between lines. Equation of a line in parametric form. Equation of a line through the intersection of two given lines. Equation of a pair of lines in the form $(a_1 x + b_1 y + c_1)(a_2 x + b_2 y + c_2) = 0$. General equation of a circle. Equation of circle through the points of intersection of (i) two circles (ii) line and circle. Equation of tangent at a point of the circle. Intersection of line and circle.

Trigonometry: Derivation and application of formulae on page 9 of Tables excluding $\ell^{in\theta}$. Domain, codomain and range of trigonometric functions. Period of a function f as the least value of $\ell > \theta$ for which $f(x + \ell) = f(x), x \in R$. The inverse functions $x \rightarrow \sin^{-1} x$ and $x \rightarrow \tan^{-1} x$.

Matrices: 2 x 2 matrices; addition, multiplication by a scalar. Product of matrices. Inverse of a 2 x 2 matrix. Application of 2 x 2 matrices to the linear transformations:– axial and central symmetry, parallel projection, rotation about origin as centre and their compositions.

Statistics: Sample point (e), sample space (S), event (E). Mutually exclusive events ($E \cap F = \phi$). The probability, P(E), of an event E is a real number satisfying:

Axiom 1:	$P(E) \geqslant 0$
Axiom 2;	$P(S) = 1, P(\phi) = 0$
Axiom 3:	$P(E) = P(E_1) + P(E_2) + \ldots + P(E_k)$, where $E = E_1 \cup E_2 \ldots \cup E_k$ and where $E_1, E_2 \ldots, E_k$ are singletons.
Theorem S1	If E and F are mutually exclusive events, then $P(E \cup F) = P(E) + P(F)$

Theorem S2 If E and F are subsets of S, then $P(E \setminus F) = P(E) - P(E \cap F)$

Theorem S3 If E and F are subsets of S, then $P(E \cup F) = P(E) + P(F) - P(E \cap F)$

Definition E and F are equally likely events $\iff P(E) = P(F)$

Theorem S4 If E is a subset of S, then
$$P(E) = \frac{\#(E)}{\#(S)}$$

Definition E and F are independent events $\iff P(E \cap F) = P(E).P(F)$

Theorem S5 If E and F are independent events, then E and F^1 are also independent events.

Binomial distribution ($\bar{x} = np$, $\sigma = \sqrt{npq}$) (proof for σ not required).

Standard units $z = \frac{x - \bar{x}}{\sigma}$

Use of Tables on page 36 to test a null hypothesis at the 5% level of significance.

OR

Vectors and Linear Transformations: Vector $\vec{ab}$ represented as the translation $\vec{ab}$. The pointed plane Π_0. The vector $\vec{x}$ is the vector $\vec{ox}$. Addition of vectors as the composition of two translations. Multiplication of a vector by a scalar. Commutative, associative and distributive laws. Length of a vector. Transformation of the plane is a map $\Pi \to \Pi$.
Linear transformation f defined by $f(a\vec{x} + b\vec{y}) = af(\vec{x}) + bf(\vec{y})$.
Orthonormal basis $\vec{i}, \vec{j}$. Scalar product $\vec{x}.\vec{y} = |\vec{x}|\ |\vec{y}| \cos\theta$.
Geometrical meaning.

Theorem V 1 Parallel projection on a line containing the origin is a linear transformation.

Theorem V 2 Scalar product distributes addition: $\vec{x}.(\vec{y} + \vec{z}) = \vec{x}.\vec{y} + \vec{x}.\vec{z}$

Deduction: $\vec{x} = x_1\vec{i} + x_2\vec{j}, \vec{y} = y_1\vec{i} + y_2\vec{j} \Rightarrow \vec{x}.\vec{y} = x_1 y_1 + x_2 y_2$.

Theorem V 3 If r is a point of a line ab, then $\vec{r} = t\vec{b} + (1 - t)\vec{a}$, where $t \in R$.

Deduction 1: If $r \in ab$ and $|ar| : |rb| = m : n$, where $m, n \in R$, then

$$\vec{r} = \frac{m\vec{b} + n\vec{a}}{m + n} \quad \text{if } r \in [a\ b]$$

$$\vec{r} = \frac{m\vec{b} - n\vec{a}}{m - n} \quad \text{if } r \notin [a\ b]$$

Deduction 2: If g is the centroid of a triangle abc, then $\vec{g} = \frac{1}{3}(\vec{a} + \vec{b} + \vec{c})$

Theorem V 4 In any triangle abc, the circumcentre, the orthocentre and the centroid are collinear.

Theorem V 5 If a, b, c are any three points such that $m\vec{a} + n\vec{b} + k\vec{c} = \vec{o}$ for all positions of the origin and for $m, n, k \in R$, then $m + n + k = 0$.

Analytical Geometry (Parabola): The parabola considered as a locus. The equations $y^2 = \pm 4ax$, $x^2 = \pm 4ay$. Parametric equation: $x = at^2$, $y = 2at$. Tangent to a parabola at a point of the parabola. Intersection of line and parabola. The equations $(y-c)^2 = \pm 4a(x-b)$; $(x-b)^2 = \pm 4a(y-c)$.

OR

Groups: Definition. Commutative groups. Examples of groups under the operations + and × from real numbers, 2 × 2 matrices, residue classes. Examples of groups under composition from the symmetries of an equilateral triangle and square. The group S, Δ where S is the set of all subsets of a given set and Δ is symmetric difference. Recognition of subgroups. Isomorphism of two groups.

Sequences and Series: Evaluation of simple limits assuming the theorems on sums, products and quotients of limits. Evaluation of limits as $x \to a$. Sequences, including arithmetic and geometric with applications to repayment of loans, including use of compound interest formula. Convergence and divergence of sequences. Series including arithmetic and geometric. Convergence and divergence of series. Comparison and ratio tests for series of positive terms.

Calculus: Differentiation: Derivatives from first principles. Rate of change. Derivatives of products, quotients, composite functions (function of a function), polynomials. Local maxima and minima. Points of inflexion. Elementary curve sketching, including parabola and ellipse in standard form. Derivative of (i) trigonometric functions (ii) inverse trigonometric functions $\sin^{-1}$, $\tan^{-1}$ (iii) exponential function (iv) logarithmic function (v) parametric functions of the form $x = f(t)$, $y = g(t)$.

Calculus: Integration: Integration of x^r and of polynomials; trigonometric functions and functions of the form $\sin^2 mx$, $\sin^3 mx$, $\sin mx \cos^2 mx$; the exponential function e^{kx}, k a constant; functions of the form

$$\frac{1}{x^2+a^2}, \quad \frac{1}{\sqrt{a^2-x^2}}; \quad \sqrt{a^2-x^2}$$

product of sines and cosines of multiple angles. Use of substitution. Definite integrals with application to areas and volumes of revolution.

Note: Statistics is an alternative to Vectors and Linear Transformations. Analytical Geometry (Parabola) is an alternative to Groups.

APPENDIX B

MATHEMATICAL STUDIES : SYLLABUSES AND RELATED MATERIAL

F.S.E. MATHEMATICAL METHODS 1

This course attempts to provide a rational basis for studying mathematics in the Science context. The value of mathematics in problem situations is demonstrated and refined by a systematic approach to problem solving. The mathematical model emerges as a key concept and is investigated. Necessary mathematics is developed and facility in numerical techniques is expected. The whole course emphasises learning with understanding. This course is seen as suitable preparation for those who wish to use mathematics as a tool in the Sciences, and also for intending teachers of mathematics as it provides experience of an essential aspect of mathematics i.e. its use in Science.

Syllabus

Review	:	Algebraic techniques, numbers, powers, logs, scientific notation, significant figures, rounding, slide rule, reading mathematical tables.
Coordinate Geometry	:	Functions, graphs, straight line, distance slope, circle, parabola, hyperbola
Experimental Laws	:	Determination of experimental laws, graphical techniques, linear graphs, expressions reducible to linear form, semi-log, log-log graphs
Problem Solving	:	Systematic Approach to problem solving, block diagrams, flow charts, alogrithm
Models	:	Non-mathematical models, Theoretical models, mathematical models, solving mathematical models, advantages in modelling, examples, total process from scientific viewpoint, applications.

Selected Bibliography

Text

Bajpai, A.C. et al	Engineering Mathematics John Wiley & Sons 1974

Other References

Ayres, F.	Calculus Schaum Publishing Co 1972
Jackson, K.F.	The Art of Solving Problems Heinemann, 1975
Lang, S.	A First Course in Calculus Addison-Wesley, 1964
Pugh, E.M. Winslow, G.H.	The Analysis of Physical Measurement Addison-Wesley, 1966

International Journal of Mathematics in Science and Technology
Physics Education

Contribution to Programme

- Makes a direct and specific contribution to the development of numeracy in the student-teacher
- Provides essential mathematical tools for use in Science Courses
- Provides a rational basis for use of mathematics and importance of mathematics in Science.

F.S.E. MATHEMATICAL METHODS 11

This course is a continuation of Mathematical Methods 1. Mastery of techniques with understanding is sought. Mathematical concepts are introduced because of their applicability in future mathematics courses and in Science

Syllabus

Coordinate Geometry	: Review of coordinate geometry
Derivative	: Newton Quotient, limits, derivative differentation techniques
Applications of the Derivative	: Chain Rule, velocity, acceleration, small errors, maxima and minima
Special Functions	: Trigonometric Functions, Exponential and log functions
Partial Derivatives	: Differentials, partial derivatives, total differentials, propogation of errors
Integral	: Primitive, Indefinite integral, area, elementary integration techniques.

Selected Bibliography

Text

Bajpai, A.C. et al — Engineering Mathematics John Wiley & Sons, 1974

Other References

Ayres, F. — Calculus
Schaum Publishing Co 1972

Jackson, K.F. — The Art of Solving Prolbems
Heinemann 1975

Lang, S. — A First Course in Calculus
Addison-Wesley, 1964

Pugh, E.M. Winslow, G.H. — The Analysis of Physical Measurement
Addison-Wesley, 1966

International Journal of Mathematical Education in Science and Technology
Physics Education

Contribution to Programme

- Makes a direct and specific contribution to the development of numeracy in the student teacher

- Provides foundational work for the Calculus

F.S.E. CALCULUS

This course is intended as a first course in mathematical analysis. While attention is focussed on mathematical rigour it is never the overriding consideration. Many theorems are proved which contribute to the development of the course. Numerical methods are used throughout. Special consideration is given to applications.

Syllabus

Functions, Limits, Continuity	: Idea of a function, selected functions, notion of limit, graphs of continuous curves.
Coordinate Geometry and Graphs	: Cartesian system, graph, graphs of selected functions, straight line, circle, parabola, hyperbola, polar coordinates
Differentiation	: Tangent, Newton Quotient, derivative, techniques M.V.T., maxima and minima applications
Integration	: Definition, properties, fundamental theorem, techniques, applications
Infinite Series	: Introduction, convergence, ratio test, Maclaurin's series, manipulations with series, differentiation and integration, use of series for approximations and obtaining limits, L'Hospital's Rule, Taylor's Series.
Partial Differentiation	: Function of two variables, partial derivative, second partial derivatives, small increments and errors, total derivative, differentials.

Complex Numbers : Need, definition, laws, conjugate, modulus, roots, argand diagram, triangle inequality, complex variable z, arg z, de Moivre's theorem, Euler's formula, polar form of z, roots of unity

Elementary Functions of z : e^z, Cos z, Sin z, Log z

Selected Bibliography

Text

Bajpai, A.C. et al : Engineering Mathematics
John Wiley & Sons 1974

Other References

Ayres, F. Calculus
Schaum Publishing Company 1972

Lang, S. A First Course in Calculus
Addison-Wesley, 1964

Lang, S. A Second Course in Calculus
Addison-Wesley, 1964

Spiegel, M.R. Advanced Calculus
Schaum Publishing Company 1974

Contribution to Programme

- It provides substantially, the necessary mathematical background for a wide range of applications
- It is highly functional in relation to the secondary school environment

F.S.E. ORDINARY DIFFERENTIAL EQUATIONS

This is an elementary course in differential equations. Emphasis is on solution techniques of a specific nature. The applications value is highlighted and facility in the formulation of differential equations from real situations is expected. The material is presented as a further application of the Calculus on one hand, and an essential development on the other.

Syllabus

First Order d.e.'s	:	Introduction, order, degree, solution elimination of constants, general solutions boundary and initial conditions, particular solution, applications
Types of First Order d.e.'s	:	Variables separable, homogeneous, linear, exact
Second Order d.e.'s	:	Introduction, second order d.e's with constant coefficients, method of trial solutions, d-operator methods, applications

Selected Bibliography

Text

No Specific Text

Other References

Ayres, F.	Differential Equations Schaum Publishing Co 1972
Bajpai, A.C. et al	Mathematics for Engineers and Scientists Vol. 1 and 2 John Wiley & Sons, 1973
Bajpai, A.C. et al	Ordinary Differential Equations John Wiley & Sons, 1970
Piaggio, H.J.H	Differential Equations G. Bell & Sons, 1965

Contribution to Programme

- It has a high applications value
- It is a further development of the Calculus
- It contributes to the personal mathematical education of the student

F.S.E. ALGEBRAIC STRUCTURES

The main theme of this course is the study of group structure. The familiar number systems are developed from an axiomatic point of view and it is from a study of the properties of these systems that the group structure emerges. Set theory is considered a necessary prerequisite and for that reason, as well as others, is studied from the outset.

Syllabus

Mathematical System	:	Undefined terms, axioms, definitions, theorems
Mathematical Proof	:	Implication, opposite, converse, contrapositive, necessary and sufficient conditions, reductio ad absurdum, quantifiers
Algebra of Sets	:	Concept of Set, notation, equivalence, relations, mappings, subsets, set operations, Venn diagrams, partition, laws, applications, Linear inequalities
Number Systems	:	Natural numbers, cardinal and ordinals, Peano's axioms, properties of natural numbers, mathematical induction, extensions of the number system, integers, rationals, reals, irrational numbers
Groups	:	Binary operations, groupoids, semi-group, abelian, order, identity and inverses, homomorphism, isomorphism, Cayley's Theorem, Groups, group axioms, subgroups, permutation group.

Selected Bibliography

Text

Bell, A.W.	Algebraic Structures Allen & Unwin, 1966

Other References

Baumslag, B and Chandler, B.	Group Theory Schaum Series, McGraw-Hill 1968
Rueff, M. and M. Jeger	Sets and Boolean Algebra Allen & Unwin, 1970
Schaeff, W.L.	Basic Concepts of Elementary Mathematics John Wiley & Sons, 1969

Contribution to Programme

- It is functional in relation to the school environment
- Makes a direct and specific contribution to the development of literacy in Modern Mathematics in the student-teacher
- Provides essential foundation for a synoptic view of Mathematics

F.S.E. LINEAR ALGEBRA

This is a first course in Linear Algebra. The treatment is rigourous but wherever possible is motivated by geometric considerations. Theorems which have a significant pedagogical content are included and proved. The main emphasis is on linear systems.

Syllabus

Linear Systems	: Linear Equations, systems of linear equations, consistency, gaussian elimination, homogeneous systems matrices, matrix operations
Determinants	: Determinant function, properties, co-factor method, Cramer's rule
Vectors	: Vectors in 2-space and 3-space geometric setting, algebraic setting, vector arithmetic, norm, dot product, projections, cross products, lines and planes
Vector Spaces	: Euclidean n-space, vector spaces, subspaces, linear independence, basis and dimension, row space of A matrix, finding bases, orthogonal bases
Linear Transformations	: Definition, properties, kernal, range, dimension theorem, matrices of linear transformations, change of basis
Eigenvalues	: Eigenvalues, eigenvectors, diagonalization, symmetric matrices

Selected Bibliography

Text

Anton, H. — Elementary Linear Algebra
John Wiley & Sons, 1973

Other References

Ayres, F. — Matrices
Schaum Publishing Company 1962

Lang, S. — Linear Algebra
Addison Wesley 1970

Spiegel, M.R. — Vector Analysis
Schaum Publishing Company 1959

Contribution to Programme

- It is functional in relation to the school environment
- It is Applicable Mathematics
- It Provides a unifying theme which is necessary for a synoptic view of mathematics.

F.S.E. STATISTICS AND PROBABILITY

This course is intended to provide the student with a sound background in elementary statistical techniques. Understanding is stressed as the best possible approach to applications although facility in techniques is expected. Uses and abuses of Statistics are considered. The course is decidedly Statistics-oriented, however, necessary probability theory is developed to facilitate understanding.

Syllabus

Descriptive Statistics	:	Frequency distributions, sigma notation, central tendency, dispersion
Probability Theory	:	Classical definition, relative frequency definition, spaces, events, expectation, permutations and combinations
Probability Distributions	:	Binomial, Normal, Poisson Distributions
Estimation Theory	:	Parameters, unbiased estimates, efficient estimates, point estimators, confidence intervals
Decision Theory	:	Statistical decisions, statistical hypotheses, tests of hypotheses, significance, one and two-tails tests
Small Sampling Theory	:	Student's t-distribution, chi-square distribution
Correlation Theory	:	Curve fitting, least squares, scatter diagram, linear regression, correlation

Selected Bibliography

Text

Chatfield, C. — Statistics for Technology
Penguin, 1970

Other References

Crocker, A.C. — Statistics for the Teacher
Penguin, 1969

Spiegel, M.R. — Statistics
Schaum Publishing Company, 1961

Turner, J.C. — Modern Applied Mathematics
English Universities Press, 1970

Contribution to Programme

- It is highly functional in relation to school environment
- It highlights the fact that Mathematics finds application even in non-scientific areas i.e. Social Sciences and Humanities

F.S.E. COMPUTER STUDIES

This is decidedly a computer appreciation course and is in no sense directed towards the training of computer programmers. However, this course is built on the premise that appreciation is facilitated by doing and hence the inclusion of programming as a topic and activity. The computer is treated as an information processing system.

Syllabus

Information Processing	:	Organisation and presentation of information, algorithm, problem definition, flow charts
Binary Arithmetic	:	Conversion from base 10 to binary and vice-versa, Alphanumeric characters, numbers and instructions in binary form
Concept of a Program	:	Analysis of flow charts, source program, object program, programming language
Structure and Organisation	:	Memory, arithmetic unit, control, I/O storage of program, bits, bytes, words
Hardware	:	I/O devices, immediate access store, backing store
Software	:	Assemblers/Compilers, operating systems, program library
Programming	:	Writing simple programs in a high level language, either FORTRAN or BASIC

Computer Applications : Scientific, business, other applications, computer industry, computer developments

Selected Bibliography

Text

Bajpai, A.C. et al	Fortran and Algol John Wiley & Sons 1972

Other References

Bohl, M.	Information Processing Science Research Associates, 1971
Farina, M.V.	Programming in Basic Prentice-Hall, 1968
Hawkes, N.	The Computer Revolution Thames and Hudson, 1971
Hollingdale, S.H and G.C Tootill	Electronic Computers Pelican, 1970
McCracken, D.D.	A Guide to Fortran IV Programming Wiley, 1972 (2nd Edn.)

Contribution to Programme

- It is functional in relation to the school environment
- It has great applications value both within Mathematics and outside it
- It equips students to come to grips with one of the most significant recent technological developments as it relates to society

F.S.E. TRANSFORMATION GEOMETRY

This course is in harmony with the modern approach to Geometry. For the first time the student is faced with the possibility of non-Euclidean geometries. Mathematical structures are emphasised and the Group Structure in particular. Simplicity and generalisation in Mathematics are stressed

Syllabus

Mappings	:	One-one, onto, image, inverse, parallel projection, orthogonal projection, permutations, transformation
Reflection in a Line	:	Definition, axis of reflection, properties, Fermat's principle, combination of transformations, identity and inverse transformation, involutary mapping, symmetry, axis of symmetry, centre of symmetry, congruences
Translations	:	Definition, vectors, direct isometries, combination of translations, half-turns vector addition, groups, sub-group
Rotations	:	Definition, angle of rotation, centre of rotation, directed angle, properties of rotation, combination of rotations
Group of Isometries	:	Congruency, reflexivity, symmetry, transitivity, equivalence relation, equivalence classes, parallelism, direct and opposite isometries

Group of Transformations : Mapping a square onto itself

Enlargements : Definition, properties, enlargements applied to geometric locus, scale factor, combination of enlargements

Similarities : Spiral similarity, similarity, direct and opposite, stretch-reflection, group of all similarities, Euclidean geometry.

Selected Bibliography

Text

Jeger, M. — Transformation Geometry
George Allen & Unwin, 1964

Other References

Kline, M. — Mathematics for Liberal Arts
Addison-Wesley, 1967

Marjoram, D.I.E. — Modern Mathematics in Secondary Schools
Pergamon Press, 1965

Schaaf, W.L. — Basic Concepts of Elementary Mathematics
John Wiley & Sons 1969

Contribution to Programme

- It is functional in relation to the school environment
- It contributes to the development in the student of a synoptic view of Mathematics

F.S.E. GRAPH THEORY

This is an elementary course in Graph Theory. The theme is that an uncomplicated theory can still be a powerful one in relation to mathematics and its applications. Every effort is made to apply the theory, and theory is developed in light of important applications.

Syllabus

Graphs	:	Introduction, examples, local structure, isomorphic graphs, simple graph, undirected graph, complete graph, null graph, infinite and finite graphs, handshaking lemma, subgraph
Graph Types	:	Discussion of various important graph types e.g. null graph, complete graph, regular graph, cubic and Petersen graphs, Platonic graphs
Geometric Realizations of Graph	:	Embedding of graphs, geometric realization planar graphs, Jordan Curve Theorem, crossings, explicit construction for the embedding in 3-space
Connected Graphs	:	Paths, chains, circuits, connected graph, disconnected graphs, connected components, algorithm for finding connected components of any graph, union of graphs, sum, applications
Euler Graphs	:	Disconnecting set, cut set, isthmus, Euler Graph, Important Theorems, Konigsberg Bridge Problem, Fleury's Algorithm, Hamiltonian Circuit

Trees and Forests	:	Trees, and forests, various equivalent definitions, number of edges, spanning tree, spanning forest, circuit rank, applications of trees, sorting
Bipartite Graphs	:	Bipartite and k-partite graphs, complete, matchings, Hall's Theorem (Marriage Problem)
Directed Graphs	:	Arc, path, cycle

Selected Bibliography

Text

Wilson, R.J. — Introduction to Graph Theory, Oliver & Boyd, 1972

Other References

Busacker, R.G. and Saaty, T.L. — Finite Graphs and Networks, McGraw-Hill, 1965

Ore, O. — Graphs and Their Uses, Random House, 1963

Contribution to Programme

- It contributes significantly to a synoptic view of mathematics
- It serves as an application of set theory
- It has a high applications value

F.S.E. MATHEMATICS SEMINAR

This is a loosely structured course where students will be encouraged to formulate a synoptic view of Mathematics. An attempt will be made to present a comprehensive view of the Mathematics Programme in relation to its component parts. Many general as well as unifying themes will be developed. This course is seen as necessary follow-up to courses in the programme in that it builds on ideas already introduced in courses but because of the different emphasis in individual courses could not be actively pursued at the first encounter.

Syllabus

There is no syllabus as such for this course but the following sample topics will serve as an illustration of what is intended:-

The nature of mathematical thinking
Mathematical Structures
Number
Generalisation in Mathematics
Mathematical Modelling

Contribution to Programme

- It promotes a synoptic view of Mathematics
- It adds to the student's understanding of the Mathematics Programme
- It encourages the student to become acquainted with important sources of relevant information

APPENDIX C

DRAFT SYLLABUS FOR COMPUTER EDUCATION

for

SECONDARY SCHOOLS IN IRELAND

Section 1 : Information about the Computer

Hardware : Input-Output Devices
Backing Store, Additional Equipment
such as VDU, Graph-plotter.

Software : Assemblers/Compilers
Operating Systems, Program Library,
Software Packages.

Computer Installation.

Section 11 : Elements of Technology

Switching Circuits, Logic Gates
Simple ideas of Storage, Magnetisation

Section 111 : Programming

Programming in LOW and HIGH level languages.
Flow Diagrams.

Section 1V : Computer Applications

General Appreciation of Applications in
Commercial, Industrial, Scientific, Humanistic
and Mathematical fields.

Section V : Social Impact

Popular Image; The Press, Personnel,
Threats to Privacy

Section V1 : Related Topics

History of the Development of Calculating Aids, Number Systems especially Binary. Careers available in the Computer World.

Further Notes on Section 111 :

Section 111 can be subdivided as follows:

1. Flowcharting
2. Programming Languages
3. Mathematics
4. Sciences; (a) Chemistry (b) Physics (c) Biology
5. Geography
6. Business Studies

APPENDIX D

HISTORY OF MATHEMATICS COURSES[1]

1. The courses described in Appendix B taken together with those in Appendix D constitute the author's most recent (1978) attempt to devise a mathematics curriculum along the lines described in Chapter IX.

F.S.E. HISTORY AND NATURE OF MATHEMATICS 1

This is the first in a series of three short courses. Here the emphasis is on the nature of mathematics; its concepts, structures and abstractness. The contributions of early cultures is examined with a view to establishing their part in determining the nature of mathematical knowledge.

Syllabus

Early Civilizations	:	The mathematics of the Egyptians, and Babylonians
Greek Influence	:	The Classical Greek period, Alexandrian Greek period, negative influence of the Romans
The Hindus and Arabs	:	The Arab contribution. Hindu numeral system, zero, positional notation.
Early and Medieval Europe	:	Events during this period. Non existence of art, science, mathematics
The Renaissance	:	Important social developments, Influence of artists, Kepler
From 1550-1800	:	The development of Algebra, logarithms coordinate geometry calculus
1800 - Present	:	Expansion of science and mathematics non-Euclidean geometry, complex numbers, matrices, n-dimensional space

Concepts of Mathematics	:	Abstractions, number, geometrical form, structure
Sources of Mathematical Knowledge	:	Sources of knowledge, methods of reasoning, mathematical proof axiomatic systems

Selected Bibliography

Text

No Specific Text

Other References

Kline, M.	:	Mathematics for Liberal Arts Addison-Wesley 1967
Kline, M.	:	Mathematics in Western Culture Penguin 1972
Schaaf, W.L.	:	Basic Concepts of Elementary Mathematics Wiley, 1969 (Third Edition)

Contribution to Programme

- It introduces and causes students to think about the foundations of mathematics
- It gives the students a historical sketch of the development of mathematics
- It contributes to a synoptic view of mathematics

F.S.E. HISTORY AND NATURE OF MATHEMATICS 11

This is the second in a series of three short courses. Here important contemporary mathematical areas are singled out and their development is traced so far as this is possible. Biographical data on famous mathematicians is included when a person's individual contribution is examined.

Syllabus

Number	:	Concept of number, number systems, natural numbers up to reals. Zero, place value complex numbers
Algebra	:	Stages in the development of Algebra
Analytic Geometry	:	Descartes, Rectangular Coordinate systems, importance of this idea
Calculus	:	Early developments, Newton and Leibnitz, rigourization
Set Theory	:	Cantor, importance of sets, set Theory and mathematics

Selected Bibliography

Text

No Specific Text

Other References

Bell, E.T. Men of Mathematics
Simon and Schuster 1937

Boyer, C.B.	The History of the Calculus and its Conceptual Development Dover, 1949
Hooper, A.	Makers of Mathematics Faber and Faber, 1959
Schaaf, W.L.	Basic Concepts of Elementary Mathematics Wiley, 1969 (Third Edition)

<u>Contribution to Programme</u>

- It provides historical information on the development of a number of areas of mathematics included in the programme

- It contributes to a synoptic view of mathematics

F.S.E. HISTORY AND NATURE OF MATHEMATICS 111

This is the third and last course in a series of three short courses. The emphasis here is on pinpointing great ideas in the evolution of mathematics. Sometimes these led to or constituted what might be termed revolutions in mathematical thought. Their greatness and/or revolutionary character is examined. The aim is that these ideas should not go unnoticed as is often the case.

Syllabus

Number	:	Concept of number, Hindu-Arabic numerals, zero, place value, decimal notation
Algebra	:	Variable, operations, structures
Calculus	:	Differential and integral calculus, rates of change, implications for Applied Mathematics
Geometry	:	Euclidean Geometry, Analytical Geometry, non-Euclidean geometry, Transformation Geometry
Set Theory	:	Theory of the Infinite, rigourization, paradoxes, Modern Mathematics
Axiom Systems	:	Axioms, definitions, theorems, deductive reasoning, power and limitations of, implications of Godel's Theorem

Selected Bibliography

Text

No Specific Text

Other References

Hooper, A.	Makers of Mathematics Faber and Faber, 1959
Kline, M.	Mathematics for Liberal Arts Addison-Wesley 1967
Newman, J.R. ed	The World of Mathematics Vol 111 Allen and Unwin 1960

Contribution to Programme

- It develops a sense of the greatness of mathematics as a human endeavour
- It contributes to a synoptic view of mathematics
- It contributes to a better understanding of the programme content

APPENDIX E

THOMOND COLLEGE DEGREE EXAMINATIONS[1]

SAMPLE OF MATHEMATICS PAPERS 1976-78

1. The author wishes to draw attention to the new-style essay type mathematics papers as these papers portray the new approach more adequately than the others.

Colaiste Oideachais Thuamhan

Thomond College of Education

Summer Examinations 1978

Science Studies

MATHEMATICS

PAPER I

PROF. A. C. BAJPAI

Candidates may obtain full marks by successfully completing any *FIVE* questions

1. Discuss the function $y = \sinh x$, the domain being the set of real numbers, under the following heads

   (i) graph (sketch)

   (ii) similarities and differences with $\sin x$

   (iii) inverse

   (iv) logarithmic equivalent of $\sinh^{-1}x$

   All conclusions must be corroborated with relevant definitions, derivations and proofs.

   (20 marks)

2. (a) Find $\frac{dy}{dx}$ in each of the following cases:

   (i) $y = \dfrac{(x^3 + 1)}{(x - 1)^6}$

(ii) $y = (\sin x)^x,\ 0 < x < \pi$

(iii) $x^2 + y^2 = a^2$ where a is a constant.

(b) Find the point of greatest curvature on the curve $y = e^x$.

(20 marks)

3. (a) Derive a reduction formula for $\int \cos^n x \, dx$ and use it to evaluate $\int_0^{\pi/2} \cos^8 x \, dx$.

(b) Find the volume of the solid of revolution generated by revolving about the line $x = 3$, the plane area bounded by the curve $y = x^2$, the x-axis and the line $x = 3$.

(20 marks)

4. (a) Derive an expression for the product of two complex numbers in polar form. Hence deduce a rule for division of complex numbers in polar form.

(b) Use mathematical induction on the polar form of complex numbers to prove De Moivre's Theorem that, for all positive integers n

$$(\cos \theta + i \sin \theta)^n = \cos n\theta + i \sin n\theta$$

(c) Find the sixth roots of 64.

(20 marks)

5. A chemical reaction is modelled adequately by the differential equation $\dfrac{dx}{dt} = b\,(5 - x)^2$ where

x is the change in the concentration at time t and b is the reaction rate constant.
Initially x is zero and is found to have value $x = 1$ when $t = 5$. Find the value of b and the values of x when $t = 25$ and $t = 100$. Find the limit of x as $t \to \infty$

(20 marks)

6. (a) Derive the standard result

$$f(D)e^{\alpha x} V = e^{\alpha x} f(D + \alpha)V$$

where $D = \frac{d}{dx}$, f(D) is a polynomial with constant coefficients, V is a function of x and α is a constant.

(b) Given the equation $A\ddot{x} + \frac{x}{B} = C \cos pt$, A, B, C, p being constants, and that $p^2 \neq a^2$ where $a^2 = 1/AB$, show that

$$\frac{C \cos pt}{A\,(a^2 - p^2)}$$

is a particular integral. Find a solution x of the equation subject to the initial conditions

$x = 0 = \dot{x}$ when $t = 0$.

(20 marks)

7. (a) Prove that a disconnecting set F in a connected graph G = (V,E) is a cut set if and only if G′ = (V,E−F) has exactly two components.

(b) Show that an edge of a connected graph is an isthmus if and only if it is contained in no circuit.

(c) Use the concept of disconnecting set to characterize bipartite graphs.

(20 marks)

8. (a) Prove that a connected graph $G = (V,E)$ is Eulerian if and only if the degree of every vertex of G is even.

(b) Construct an Euler graph with $\delta(\upsilon) = 4$ for every vertex υ and identify an Eulerian path through the graph.

(20 marks)

Colaiste Oideachais Thuamhan

Thomond College of Education

Summer Examinations 1978

B.A. DEGREE EXAMINATION

Science Studies

MATHEMATICS

PAPER II

PROF. A. C. BAJPAI

Candidates may obtain full marks by successfully completing *ALL* questions.

1. (a) Given an $n \times n$ invertible matrix A. Prove that the system $AX = B$ has exactly one solution $X = A^{-1}B$ for each $n \times 1$ matrix B.

(b) Given $A = \begin{bmatrix} 3 & 1 & 2 \\ 1 & 3 & 4 \\ -1 & -2 & 0 \end{bmatrix}$ Find A^{-1}

(c) Solve the system of equations:

$$\begin{aligned} 3x_1 + x_2 + 2x_3 &= 1 \\ x_1 + 3x_2 + 4x_3 &= -2 \\ -x_1 - 2x_2 &= 3 \end{aligned}$$

(20 marks)

OR

(a) If $T : V \longrightarrow W$ is a linear transformation such that $T(\vec{v}_i) = \vec{0}$ for $i = 1, 2, \ldots, n$ where $S = \{\vec{v}_1\ \vec{v}_2 \ldots, \vec{v}_n\}$ is a basis for V then prove that T is the zero transformation.

(b) If T : V$\longrightarrow$W is a linear transformation show that the kernel of T is a subspace of V.

(c) Determine the rank and nullity of the linear operator T on an n — dimensional vector space V defined by $T(\vec{x}) = 3\vec{x}$

(20 marks)

2. (a) Show that the zero element in the natural number system is unique.

(b) Show that $\alpha + 0 = \alpha$ and $\alpha . 0 = 0$ for all integers α.

(c) For $\alpha, \beta \in Z$ show that $\alpha - \beta$ exists for all integers α, β and is unique.

(20 marks)

OR

(a) Show that the set of all 2 $\times$ 2 matrics of the form $\begin{bmatrix} a & b \\ -b & a \end{bmatrix}$ where a, b are real, forms a group under matrix addition.

(b) Discuss the set B = $\{ a + bi \mid a,b \in R$ and $i^2 = -1 \}$ under addition of complex numbers.

(c) Effect a unification of (a) and (b) on the basis of some fundamental mathematical principle.

(20 marks)

3. (a) Prove that the composition of two translations is a translation and that the operation is commutative.

(b) Show that the set of all translations comprises a group.

(c) Use translations to prove that vector addition is associative.

(20 marks)

OR

(a) Prove that the product of $M_q M_p$ of reflections in two non-parallel lines p and q respectively, is a rotation about 0, the point of intersection of p and q. with angle of rotation twice the directed angle between p and q.

(b) Show that any rotation R $(0, \theta)$ may be expressed in infinitely many ways as the product of two reflections.

(c) Show that rotations and translations taken together form a group under composition of mappings.

(20 marks)

4. Explain the following terms:-

(i) compilation	(v) object program
(ii) execution	(vi) storage
(iii) syntax	(vii) software
(iv) errors	(viii) hardware

OR

Draw a flow chart and write a complete computer program including input and output which will compute roots of the equation

$$f(x) = \sinh x + \sin x - 3 = 0$$

using Newton-Raphson iteration formula

$$x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$$

and supply an appropriate initial value and suitable stopping criterion.

(20 marks)

5. (a) State the conditions under which the binomial model is applicable

(b) If 15% of screws produced by a machine are defective determine the probability that out of five screws chosen at random:

(i) one will be defective

(ii) at most two will be defective.

(c) Find the mean and standard deviation for the distribution of defective screws in a total of 250.

(20 marks)

OR

A machine has consistently produced washers having a thickness of .050 cm in the past. A spot check on the machine yields the following sample of ten washers with recorded thicknesses:

.050 cm	.052 cm
.050 cm	.050 cm
.051 cm	.056 cm
.055 cm	.056 cm
.056 cm	.051 cm

Using appropriate levels of significance test the hypothesis that the machine is in proper working order.

(20 marks)

Colaiste Oideachais Thuamhan

Thomond College of Education

Summer Examinations 1978

B.A. DEGREE EXAMINATION

Science Studies

MATHEMATICS

PAPER III

PROF. A. C. BAJPAI

Candidates may obtain full marks by successfully completing any *TWO* questions.

1. Carefully defining your terms, analyse the role of *mathematical structure* in generalizing and unifying mathematics.

2. Scarcely an area of human endeavour is unaided by mathematics. Discuss the accuracy of this statement and show cause for the pervasiveness of mathematics.

3. Identify *ONE* fundamental concept in mathematics and discuss the scope and significance of that concept for mathematics.

4. Discuss the notion of the plurality of geometries with special reference to the changed position of Euclidean geometry in the modern treatment of geometry.

OLLSCOIL NA hÉIREANN

NATIONAL UNIVERSITY OF IRELAND

COLÁISTE THUAMHAN

THOMOND COLLEGE

SUMMER EXAMINATIONS, 1977

B.Ed. DEGREE

SCIENCE STUDIES - MATHEMATICS - PAPER 111

Prof. W. Lederman
Prof. P.D. Barry
Prof. M.A. Moran
Prof. P.G. O'Regan
Dr. F. Holland

Candidates may obtain full marks by successfully completing any two questions

1. Examine the ways in which mathematical knowledge is established paying particular attention to *induction*. Distinguish between *induction* and *mathematical induction* treating the latter in detail.

2. *Counting* is a familar and routine everyday occurrence. Elaborate on the mathematical theory of counting drawing on experiences encountered in your College Mathematics Programme.

(2)

3. Discuss the various connotations of the word 'new' in the 'New Mathematics' describing with appropriate explanations departures from previous practice and their mathematical significance.

4. Applied mathematics may be interpreted to mean the search for and construction of appropriate *mathematical models* for real situations. Give an explicit treatment of the process of *mathematical modeling*.

COLÁISTE OIDEACHAIS THUAMHUMHAN

THOMOND COLLEGE OF EDUCATION

COLÁISTE NÁISIÚNTA CORPOIDEACHAIS

THE NATIONAL COLLEGE OF PHYSICAL EDUCATION

B.A. DEGREE (PART II)

EXAMINATION, AUTUMN, 1976

MATHEMATICS

PAPER II

Tuesday August 31st: 2 p.m. - 5 p.m.

Candidates are required to answer THREE questions

Answers must be presented in a concise and coherent manner; mathematical examples used must be relevant, consistent and complete.

1. Discuss the nature of mathematics paying special attention to its *concepts* and *structures* and argue plausibly in favour of the proven versatility of mathematics in applied situations.

2. Mathematics has been described as a *deductive science*. Examine the ways in which mathematical knowledge is established and then explain the relevance of the above description.

(2)

3. Discuss the nature of *mathematical proof* augmenting your discussion with descriptions of the various *proof techniques* encountered during your mathematical studies.

4. *Problem Solving* is a fundamental activity in mathematics. Show how *mathematical models* enhance the problem solving capability, and explain the special relevance of mathematical modelling in relation to the Physical Sciences.

5. Describe the evolution of the concept of *number* from the point of view of contributory mathematical developments from basic concepts, and in the exposition discuss the role of geometric models of numbers.

6. *Statistics* and *Probability* have been described each as the inverse subject of the other. Discuss the duality between the subjects paying particular attention to the role of Probability in Statistics.

External Examiner: *Professor A.C. Bajpai.*

APPENDIX F

COMPUTER STUDIES : PSI COURSE - UNIT 3

Introduction

It should be clear from the previous units that the computer can handle information only if that information is presented to the computer as a set of digits. Ultimately communication with the computer is dependent upon that fact. Information for computer processing must be condensed to representative data and instructions which in turn must be presented to the computer as a set of digits. You have been made aware that *machine languages* have been based on this notion and the interchange between person and computer was carried out by inputting the various sets of digits. This was extremely laborious work prone to error and non-transferrable as the peculiarities of each computer demanded different sets of digits for the same data. Refinements were effected over several years but the major break-through came with the advent of *high-level languages*. This arrangement allowed the user to present his information to the computer system in a form which was closer to his own mode of expression by using a special language which the computer and indeed every computer "understands". This process involves writing a *computer program* in the desired language and presenting it to the computer system. There are several languages in widespread use today viz FORTRAN, ALGOL, COBOL and BASIC but whether the computer accepts them depends largely on the size of the machine and the availability of certain software resources *(Compilers)*.

The work of translating the high-level language program into machine language is done by the compiler which "lives" in the computer or can be called upon to do its work by an instruction in the computer program.

The original computer program written in the high-level language is called the *source program* and this is translated into an *object program* in machine language by the appropriate compiler. This process must take place in all digital computers. (See Fig. 1). Let me remind you at this point lest you have forgotten, that the compiler is itself a program.

The crux of the matter then is that the problem must be prepared in a certain way prior to handing it over to the computer. This unit concerns itself with the two-fold task of explaining *how the computer system* accepts information from an *external source* and processes it *internally* in machine language. This is the problem of *data representation.*

Objective

When you have studied the material in this unit you must demonstrate your mastery of the content by demonstrating your ability to:

- explain the *data representation* problem accurately and succinctly in not more than three sentences
- distinguish without hesitation between the *source program* and *object program*
- list three different *input media* and their associated hardware without procrastination
- list two different *output media* and their associated hardware without procrastination
- describe three ways in which *electronic representation* of data may be effected inside the machine. (a schematic with appropriate labels is acceptable as a description).

- convert a given decimal number to binary and vice versa fluently and accurately
- explain the concept of a *code* in a few well chosen sentences naming at least two known codes
- represent a given decimal number in *binary coded decimal* (BCD) quickly and accurately
- list three of each, *numeric, alphabetic, special and operations characters* used in FORTRAN
- explain the concept of code-checking and give one example of such a procedure.

Procedure

You must attain the objectives set out in the previous section before being allowed to proceed. You may find the following suggestions helpful.

Suggestions for completing unit successfully

1. Study the material presented with this unit; this includes the introduction (it is not necessary to consult other sources)
2. Attempt in writing the study questions supplied
3. Review the material in view of objectives and study questions prior to attempting mastery test
4. You are now ready for mastery test !

Unit Subject Content

When a DP problem or indeed any problem including a mathematical problem is being prepared for computer processing, it must be done in a special way. A computer program is written, then recorded on some medium which is acceptable to the computer system and processed by the computer causing the results to be output in some suitable medium. There are a variety of ways in which data can be input to the computer, however, they all have something in common, it is effected by means of a *code.* The code for *punched cards* is given as the presence or absence of holes in certain locations i.e. data can be recorded as holes on punched cards. The same is true of *paper tape.* Data is recorded as spots on *magnetic tape.* Sometimes *magnetic-ink characters* are used. None of these methods can be effective unless the computer system has as part of its hardware the appropriate *input device.* In the first instance *card punches* are needed to produce punched card input and these are generally *off line* from the computer. A *card reader* is required for punched cards and the reader *reads* electronically by use of brushes or photo-electric tubes. The device associated with magnetic tape input is known as a *tape drive.* Paper tape requires its own kind of tape drive. Very few systems will have such an elaborate configuration as to include all the input devices but usually more than one is available. This is no great restriction as there are means whereby data recorded in one medium can be transferred to another medium and thus there is a great deal of flexibility. You will be using the Burroughs 1700 Computer at NIHE and the following input devices are available:

- card punches
- card reader
- tape drive (magnetic)
- tape drive (paper)

Output devices are as varied as input devices and some serve a dual purpose, however most installations have a *line printer,* tape drive and/or *discs*. Discs look very much like long playing records and a *disc-unit* very much like a record player. This mode is used for both input and output and is available at NIHE with the B1700 computer. It is important at this point to establish the sequence followed as the computer accepts and processes data. This sequence is displayed schematically in Fig. 2, for an on-line and off-line system.

You have seen how the system accepts information from an external source but how does the *machine* i.e. computer represent the coded instructions internally ? You have already been made aware of the fact that everything ultimately must be represented by sets of digits. This is indeed the case but how is this effected inside the computer. Data is represented *electronically* within the machine. *Electronic representation* may be accomplished in several ways. Take for example, an *electric switch* it may be *open* or *closed*. , Thus using an electic switch we can represent two possible states without ambiguity. *Transistors* are either *conducting* or *non-conducting*. *Magnetic materials* are *magnetized* in one direction on in the opposite. *Voltages* are *present* or *not* (See Fig. 3). Data representation is accomplished by assigning a value to each of two *(binary)* indications.

The *binary method of representation* requires only *two* symbols, 0 and 1 and this two-symbol arithmetic is highly developed today:

0 represents the absence of an assigned value

1 represents the presence of an assigned value

The symbols 0 and 1 are called *bits* and *binary digits*. Thus every instruction or datum is represented internally by a string of bits.

Every decimal number can be converted to binary and vice versa. This operation depends largely upon the understanding of the familar concept of *place value* in number systems. Conversion from base 10 i.e. (*denary*) numbers to base 2 (*binary*) is accomplished by repeated division by 2 and simultaneous recording of the remainders at each stage. The binary number is obtained by reading the remainders. The technique is illustrated below for the number 14:

$$\begin{array}{r|l} 2 & \underline{14} \\ 2 & \underline{7} + 0 \\ 2 & \underline{3} + 1 \\ 2 & \underline{1} + 1 \\ & 0 + 1 \end{array} \uparrow \qquad 14_{10} = 1\,110_2$$

Read in this direction

Binary-to-decimal conversion is accomplished simply by using the meaning of place value:

$$\begin{aligned} 1\,110_2 &= (1x2^3) + (1x2^2) + (1x2^1) + (0x2^0) \\ &= 8 + 4+2 + 0 \\ &= 14 \end{aligned}$$

You have already seen that all data including instructions have to be *coded* in sets of digits. These digits are binary digits i.e. strings of zeros and ones. Any method used to represent data is known as a *code* or *coding system*. The decimal digits 0,1,2,...., 9 may be coded in binary as follows:

Decimal Digit	Binary
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1

Thus every decimal digit in a given number may be expressed in its equivalent binary form e.g. the decimal number 265498 may be represented as follows:

Decimal Digit	2	6	5	4	9	8
Binary value	0 0 10	0 1 1 0	0 1 0 1	0 1 0 0	1 0 0 1	1 0 0 0

This system is known as *binary coded decimal* (BCD) and is still used in some computers today. Why use blocks of four bits? Four bits are required to go to 9 in binary code. You can see now how all *numeric* data might be represented in the computer but what about non-numeric data? Use of high-level languages demands that the computer be capable of representing a variety of symbols both numeric and non-numeric. A high level language is written in symbols each of which must have a unique representation within the machine. For this reason each computer is designed with its own unique set of symbols called *characters* and these characters make up the computer's *alphabet* and each instruction, datum etc., must be written in terms of these *characters* and these characters *only*. These characters may be *numeric alphabetic, operations symbols or special characters*. Combinations of numeric and alphabetic characters are called *alphanumeric*. Subsets of these characters are used for the various different high-level languages. The following characters are used in FORTRAN:

Alphabetic	A, B, ..., Z (Capitals only)
Numeric	0, 1, ..., 9
Operations	+ - * / **
Special characters	= ( ) , .

If a code uses SIX positions of binary to represent characters, then all characters can be represented by different combinations of six bits. Thus BCD is a six-bit code. There are eight, sixteen and thirty-two bit codes in use in modern large-scale computers. If the basic unit of information is a certain number of bits then the computer is designed with this in mind and the computer itself is always kept "aware" of its own design by the stored program that controls its operations. The number of bits in a specific code pattern depends upon the total number of characters which must be represented. The following code patterns permit representation of:

Code Pattern	No of Characters Permissible
6 bit	$2^6 = 64$
8 bit	$2^8 = 256$
16 bit	2^{16}
32 bit	2^{32}

The following terms are in widespread use today:-

byte = 8 bits

word = 32 bits

Loss of data on high speed computers is always a problem and even though modern computers are extremely reliable, checks have to be built-in as safeguards. Such checks are known as *validity checks*. This code checking takes place automatically as the data is being processed.

Each character of data is represented by a specific number of bit positions. Some codes are based on the idea that the basic unit of information (i.e. a specific number of bit positions) must always contain an *even* number of 1 bits. Different characters are made up of different combinations of 0 and 1 bits but a valid character always has an even number of 1 bits. This is known as *even parity checking*.

VALID	INVALID
1 0 1 1 0 1 0	0 1 0 1 0 1 0
0 0 1 0 0 0 1	0 0 0 1 0 0 0

Notice that a *seventh position* is needed to indicate the presence or absence of an error in a six-bit code.

Some codes are arranged so that each character is represented by different combinations of 0 and 1 bits with a valid character having an *odd* number of 1 bits. This is known as an *odd parity* check, and such codes are known as *uneven parity codes*. There are other codes but I think we have gone into the topic in sufficient detail for our purposes.

The problem of data representation has I think been explained in sufficient detail to help you to an appreciation of computers based on understanding. A more exhaustive study of this aspect of computer usage would be self-defeating as it would lead to an unrewarding study of tedious intricacies which are the domain of the dedicated computer scientist.

Study Questions

I have set out in the usual format under heading the main concepts encountered and technical terms.

List of Important Concepts

machine language	data representation
high level language	code
computer program	binary arithmetic
source program	character
object program	validity checking

List of Technical Terms

machine language	line printer
high level language	disc
computer program	machine
compiler	electric switch
software	transistor
hardware	voltage
source program	binary system
code	place value
code-checking	binary coded decimal (BCD)
punched cards	character
paper tape	alphabet
magnetic tape	numeric
magnetic-ink characters	special characters
input device	operations
output device	byte
card reader	word
tape drive	parity checking

Notice how these concepts and technical terms are used over and over again with the addition of new ones. You are now learning the vocabulary (jargon) of the computer specialist.

Answer the following questions in writing:

1. Describe how theprocess of translating from a high level language to a machine language is effected. (Use a diagram if appropriate).

2. What is a compiler and what does it do ?

3. There are two distinct stages in the data representation problem. Identify them.

4. What is a code ? Describe a code used in each stage of the data representation problem.

5. List three ways a computer system accepts data and list the corresponding hardware device necessary.

6. What does the term *output* mean. Name two output devices.

7. How is data represented internally in the computer ? List three different techniques for effecting this.

8. Convert 156 to binary

9. Convert 11111_2 to decimal

10. Use BCD to code the decimal number 16504

11. What is a character ? List all the FORTRAN characters

12. Name three widely used basic units of information in computers. How does the basic unit affect matters in relation to the actual machine ?

13. Compute the total number of characters permissible if a computer has an 8 bit basic unit.

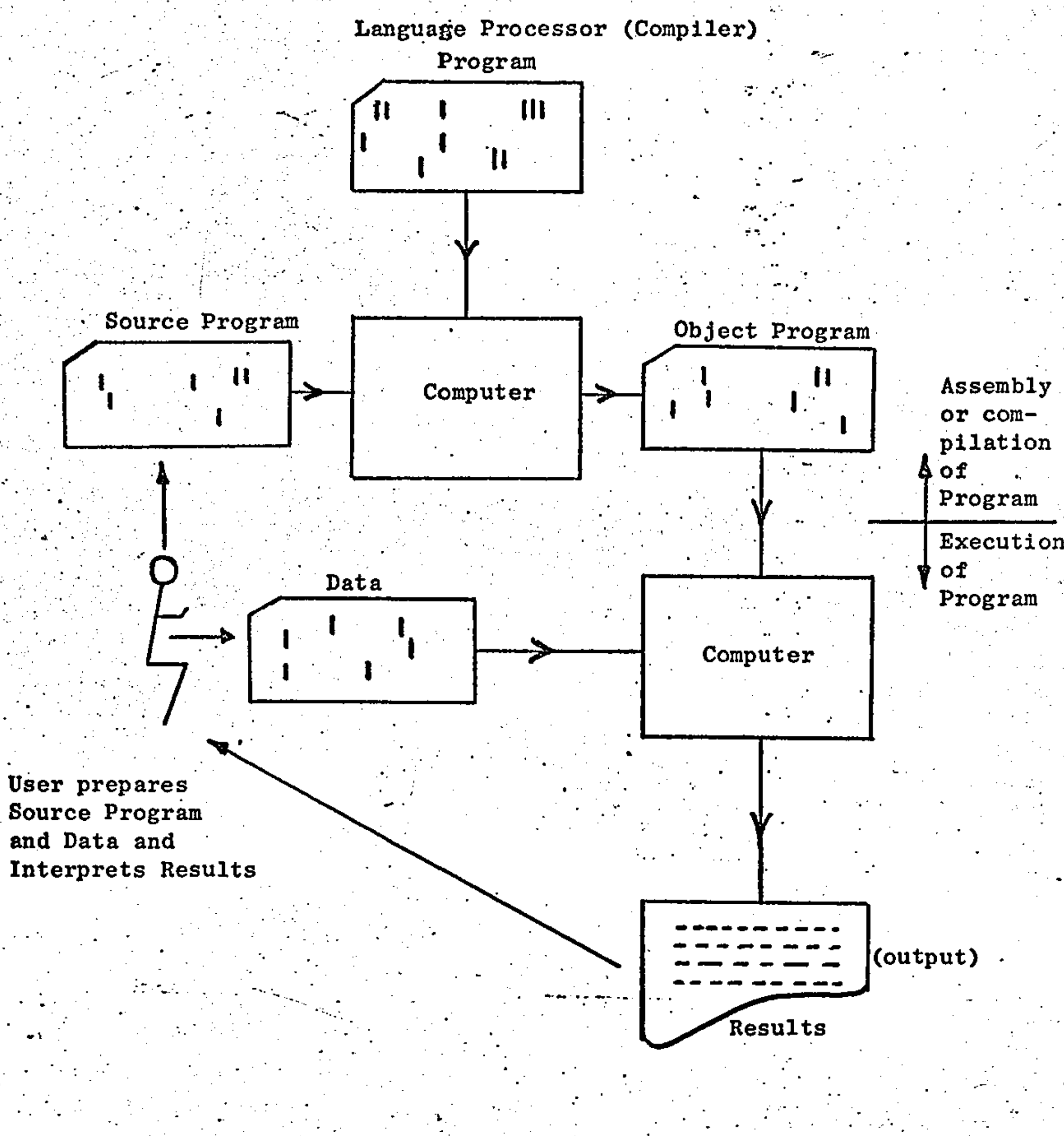
14. Describe a validity check and explain its significance.

Bibliography

This unit is based mainly on my own limited experience and the chapter entitled "data representation" in Bohl.

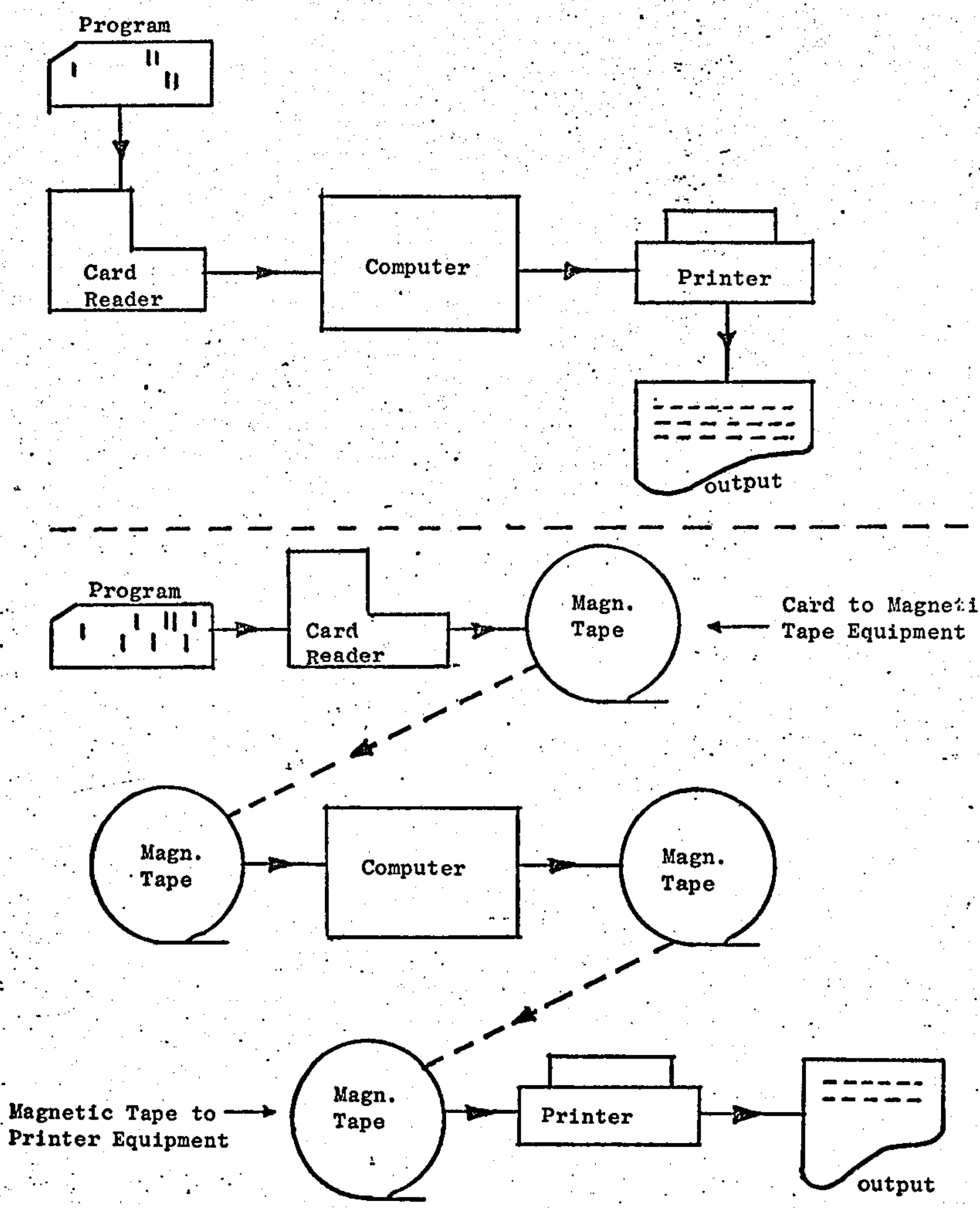
Bohl, M	Information Processing (Ch 3) Science Research Associates, Inc. 1971
Hollingdale, S.H. and Tootill, G.C.	Electronic Computers (Ch 9) Penguin 1975

FIGURE 1



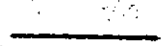
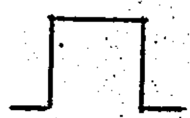
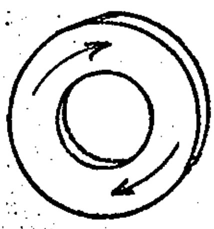
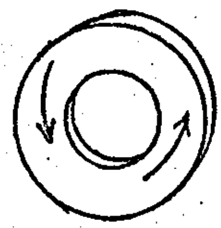
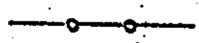
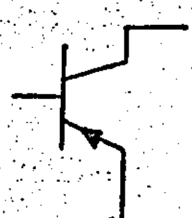
Schematic diagram of digital computer operation with a programming system

FIGURE 2



Schematic diagrams of on-line operation (above) and off-line operation (below) of a digital computer system.

FIGURE 3

Device	"0" State	"1" State
Current pulse on a wire	 No Pulse	 Pulse
Magnetic field in a magnetic core	 clockwise	 anticlockwise
Switch	 open	 closed
Transistor	 nonconducting	 conducting

Examples of binary representation in electronic components

Mastery Test 1

1. There are two parts to the data representation problem. Name them

____

____

2. The object program is a set of instructions coded in ________________ language.

3. Match the corresponding input devices associated with the following media:

Punched cards ________________

Magnetic tape ________________

Paper tape ________________

4. Magnetic tape is a multipurpose medium used for input/output and backing store

TRUE / FALSE

5. Transistors and electronic switches are used to represent data internally in the machine

TRUE / FALSE

6. Convert the decimal number 27 to binary

7. Convert 111111_2 to denary

8. Code the decimal number 2645 in BCD

9. Using an even parity check which of the following representations are valid in BCD

1001000 __________

0001110 __________

1001100 __________

10. Which of the following is not a FORTRAN character

a. 9
b. ( )
c. *
d. e

Mastery Test 1 - Key

1. Coding in a medium acceptable to computer system
   Internal machine representation in Binary

2. Machine language

3. card reader
   tape-drive
   tape-drive

4. TRUE

5. TRUE

6. $1\ 1\ 0\ 1\ 1_2$

7. 63

8. 0 0 10 0 1 1 0 0 1 0 0 0 1 0 1

9. VALID
   INVALID
   INVALID

10. e

Mastery Test 2

1. How does the computer accept information from an external source?

____

2. The source program is written in a __________ language and is translated into an object program by the __________

3. Identify each of the following hardware devices by writing input and/or output in the space provided

card reader ______________

line printer ______________

Tape drive ______________

4. An electronic switch may be open or closed thus representing without ambiguity two possible states

TRUE / FALSE

5. Binary arithmetic is a two-digit arithmetic

TRUE / FALSE

6. What is a code ?

7. Convert the decimal number 123 to binary

8. Use the concept of place value to give the decimal equivalent for 1101_2

9. Use BCD to represent the decimal number 222

10. Use an odd parity check to test the validity of the following six bit binary representations:

0 1 0 1 0 1 0

0 0 0 1 0 0 0

1 0 1 1 0 1 0

Mastery Test 2 - Key

1. The information must be coded on a suitable input medium

2. high level

3. input
   output
   input/output

4. TRUE

5. TRUE

6. a code is any method used to represent data

7. 1111011_2

8. 13

9. | 0 0 1 0 | 0 0 1 0 | 0 0 1 0 |

10. VALID
    VALID
    INVALID

Mastery Test 3

1. How does the computer accept information from an external source?

____

2. The object program is a set of instructions coded in __________ language

3. Identify each of the following hardware devices by writing input and/or output in the space provided

   card reader __________

   line printer __________

   tape drive __________

4. Magnetic tape is a multipurpose medium used for input/output and backing store

   TRUE / FALSE

5. Binary arithmetic is a two-digit arithmetic

   TRUE / FALSE

6. Convert the decimal number 27 to binary

7. Use the concept of place value to give the decimal equivalent for 1101_2

8. Use BCD to represent the decimal number 222

9. Using an even parity check which of the following representations are valid in BCD

   1001000 ______________

   0001110 ______________

   1001100 ______________

10. Which of the following is not a FORTRAN character

    a. 9
    b. ( )
    c. *
    d. e

REFERENCES AND BIBLIOGRAPHY

[1] GAGE, N.L., UNRUH, W.R. (1967). Theoretical Formulations for Research in Teaching. In, National Society for Study of Education. Review of Educational Research. Chicago, National Society for Study of Education.

[2] THE HIGHER EDUCATION AUTHORITY. (1970). Report on Teacher Education. Dublin, Stationery Office.

[3] OECD. (1966). Investment in Education - Ireland. Paris, OECD Publications.

[4] DAIL DEBATES, Vol. 202 Cols. 1375-76

[5] COMMITTEE ON THE UNDERGRADUATE PROGRAM IN MATHEMATICS (CUPM). (1960). Recommendations of the Mathematical Association of America for the training of teachers of Mathematics. *Mathematical Monthly*, 67, 982-991.

[6] ATKINSON, N. (1969). Irish Education: A History of Educational Institutions. Dublin, Allen Figgis.

[7] COUNCIL OF EDUCATION. (1954). Report of the Council of Education on (1) The function of the Primary School (2) The Curriculum to be pursued in the Primary School from the infant age up to 12 years of age. Dublin, Stationery Office.

[8] O CUIV, B. (1971) (Editor). Seven Centuries of Irish Learning 1000-1700. Cork, Mercier Press.

[9] AUCHMUTY, J.J. (1937). Irish Education: A Historical Survey. Dublin, Hodges Figgis.

[10] AKENSON, D.H. (1970). The Irish Education Experiment: The National System of Education in the Nineteenth Century. London, Routledge and Kegan Paul.

[11] COUNCIL OF EDUCATION. (1962). Report of the Council of Education on the Curriculum of the Secondary School. Dublin, Stationery Office.

[12] LYONS, F.S.L. (1973). Ireland Since the Famine. Glasgow, Fontana/Collins.

[13] O'MUIRGHIS, T.G. (1968) Education in Ireland. Issued by the Department of Education. Reprinted from the Encyclopaedia of Ireland. Dublin, Allen Figgis.

[14] O'SUILLEABHAIN, S.V. (1971). Secondary Education. In, Corish, P.J. (Editor). A History of Irish Catholicism. 5 Volumes. Dublin, Gill and Macmillan.

[15] AKENSON, D.H. (1975). A Mirror to Kathleen's Face: Education in Independent Ireland 1922-1960. Montreal, McGill - Queen's University Press.

[16] MINISTERS AND SECRETARIES ACT, 1924

[17] McELLIGOTT, T.J. (1966). Education in Ireland. Dublin, Institute of Public Administration.

[18] VOCATIONAL EDUCATION ACT, 1930.

[19] O'MEARA, J.J. (1958). Reform in Education. Dublin, Mount Salus Press.

[20] DEPARTMENT OF FINANCE. (1963). Second Programme for Economic Expansion, Part I. Dublin, Stationery Office.

[21] HILLERY, P.J. (1963). Statement in regard to post-primary education. Full text is quoted in, OECD.(1969). Review of National Policies for Education - Ireland. Paris, OECD Publications.

[22] RANDLES, E. (1975). Post-Primary Education in Ireland 1957-1970. Dublin, Veritas Publications.

[23] STEERING COMMITTEE ON TECHNICAL EDUCATION. (1967). Report to the Minister for Education on Regional Technical Colleges. Dublin, Stationery Office.

[24] INDUSTRIAL TRAINING ACT, 1967.

[25] COMMITTEE ON THE FORM AND FUNCTION OF THE INTERMEDIATE CERTIFICATE EXAMINATION. (1975). The I.C.E. Report. Dublin, Stationery Office.

[26] HIGHER EDUCATION AUTHORITY ACT, 1971.

[27] CONSTITUTION OF IRELAND. (1937). Dublin, Stationery Office.

[28] CRAFT, M. (1970). Economy, ideology and educational development in Ireland. *Administration*, 18, 363-374.

[29] OECD. (1973). Classification of Educational Systems in OECD Member Countries - Austria, Ireland, Italy. Paris, OECD Publications.

[30] KELLY, J.M. (1967). Fundamental Rights in the Irish Law and Constitution. Dublin, Allen Figgis. 2nd Edition.

[31] DEPARTMENT OF EDUCATION. (1965). Rules for National Schools under the Department of Education. Dublin, Stationery Office.

[32] DEPARTMENT OF EDUCATION. (1976). Rules and Programme for Secondary Schools. Dublin, Stationery Office.

[33] REGISTRATION COUNCIL. (1967). Regulations for the Register of the Intermediate School Teachers. Dublin, Stationery Office.

[34] DEPARTMENT OF EDUCATION. (1958). Rules for the Payment of Incremental Salary to Secondary Teachers. Dublin, Stationery Office.

[35] DEPARTMENT OF EDUCATION. (1957). Rules for the Payment of Grants to Secondary Schools. Dublin, Stationery Office.

[36] VOCATIONAL EDUCATION (AMENDMENT) ACT, 1971.

[37] NATIONAL COLLEGE OF ART AND DESIGN ACT, 1971.

[38] O'CONNOR, S. (1968). Post-Primary Education Now and in the future. *Studies,* LV11, 233-251.

[39] WHYTE, J.H. (1971). Church and State in Modern Ireland, 1923-1970. Dublin, Gill and Macmillan.

[40] BEREDAY, B.Z.F., LAUWERYS, J.A. (1966). (Editors). The World Year Book of Education 1966: Church and State in Education. London, Evans Brothers.

[41] MILLER, D.W. (1973). Church, State and Nation in Ireland 1898-1921. Dublin, Gill and Macmillan.

[42] McCARTHY, C. (1972). Schools and the Community. In, Murphy, M.W. (Editor). Education in Ireland 111: To unleash the potential. Cork, Mercier Press.

[43] PETERSEN, A.D.C. (1971). A Hundred Years of Education. London, Duckwork. 3rd Edition.

[44] IRISH TIMES, 25 Feb., 1976.

[45] COLLEY, G. (1966). Letter to the Authorities of Secondary and Vocational Schools. Quoted in full in, RANDLES, E. (1975). Post-Primary Education in Ireland 1957-1970. Dublin, Veritas Publications.

[46] DEPARTMENT OF EDUCATION. (1970). Community Schools Document. Quoted in full in, RANDLES, E. (1975). Post-Primary Education in Ireland 1957-1970. Dublin, Veritas Publications.

[47] DEPARTMENT OF EDUCATION. (1942). Organization of Whole-Time Continuation Education in Borough Urban and County Areas. Official Memorandum V.40.

[48] IRISH TIMES, 18 June, 1971.

[49] PLANNING COMMITTEE. (1974). Report to the Minister for Education on the establishment of the Teachers Council. Dublin, Stationery Office.

[50] DEPARTMENT OF EDUCATION. (1969). All Our Children. Dublin, Stationery Office.

[51] DEPARTMENT OF EDUCATION. (1977). Statistical Report. Dublin, Stationery Office.

[52] O'CONNELL, T.J. (1970). History of the Irish National Teachers' Organization 1868-1968. Dublin, I.N.T.O.

[53] O'MALLEY, D. (1967). Scheme for the Provision of free post-primary education. Quoted in full in, RANDLES, E. (1975). Post-Primary Education in Ireland 1957-1970. Dublin, Veritas Publications.

[54] HORGAN, J. (1973). Education in the Republic of Ireland. In, BELL, R., FOWLER, G., LITTLE, K. (Editors). Education in Great Britain and Ireland: A Source Book. London, Routledge and Kegan Paul.

[55] SHEEHAN, J. (1975). Educational Expenditure in Ireland. National Economic and Social Council, Report No.12. Dublin, Stationery Office.

[56] McDONOGH, K. (1977). The Way the Money Goes. *Oideas,* 17, 5-102.

[57] O CUILLEANAIN, T.A. (1968). Special Education in Ireland. *Oideas,* 1, 5-17.

[58] NATIONAL COUNCIL FOR EDUCATIONAL AWARDS. (1977). Fourth Annual Report 1975/76. Dublin, National Council for Educational Awards.

[59] THE HIGHER EDUCATION AUTHORITY. (1977). Accounts 1975 and Student Statistics 1975-76. Dublin, The Higher Education Authority.

[60] IRISH FEDERATION OF UNIVERSITY TEACHERS. (1976). University Financing in Ireland. Dublin, Irish Federation of University Teachers.

[61] ADULT EDUCATION COMMITTEE. (1973). Adult Education in Ireland. Dublin, Stationery Office.

[62] O'HEIDEAN, E. (1967). National School Inspection in Ireland: The Beginnings. Dublin, Scepter Books.

[63] IRISH EDUCATION ACT, 1892.

[64] SCHOOL ATTENDANCE ACT, 1926

[65] DEPARTMENT OF EDUCATION. (1971). Primary School Curriculum: Teacher's Handbook Part 1. Dublin, Stationery Office.

[66] OECD. (1969). Reviews of National Policies for Education - Ireland. Paris, OECD Publications.

[67] COOLAHAN, J.M. (1973). A Study of Curricular Policy for the Primary and Secondary Schools of Ireland, 1900-1935 with special reference to the Irish language and Irish History. Ph.D. Thesis, Trinity College, Dublin.

[68] DEPARTMENT OF EDUCATION. (1967). Programme for Primary Schools. Dublin, Stationery Office.

[69] COMMISSION ON TECHNICAL EDUCATION. (1927) Report of the Commission. Dublin, Stationery Office.

[70] DAIL REPORTS, Vol. 177 Cols. 470-471

[71] O'DONNABHAN, D.P. (1969). Curriculum Planning in the Comprehensive Schools: The Junior Cycle. *Oideas*. 3, 13-19.

[72] MUSSON, J.W. (1955). The Training of Teachers in Ireland from 1811 to the Present Day. Ph.D Thesis, Queen's University, Belfast.

[73] PARKES, S.M. (1970). Teacher-Training in Ireland 1811-1870. M.Litt Thesis, University of Dublin.

[74] DEPARTMENT OF EDUCATION. (1926). Report of The Department of Education for The School Year 1924-25 and the Financial and Administrative Years 1924-25-26. Dublin, Stationery Office.

[75] DURKEN, T.J. (1970). History of Irish Education from 1800 with special reference to Manual Instruction. Bala, North Wales. Dragon Books.

[76] DEPARTMENT OF EDUCATION. (1933). Report of the Department of Education 1931-32. Dublin, Stationery Office

[77] DEPARTMENT OF EDUCATION. (1932). Report of the Department of Education 1930-31. Dublin, Stationery Office.

[78] OECD. (1969). Training, Recruitment and Utilisation of Teachers, Country Case-Studies: Primary and Secondary Education, France - Ireland, - Study on Teachers. Paris, OECD Publications.

[79] IRISH LABOUR PARTY AND TRADE UNION CONGRESS. (1925). Labour's Policy on Education. Dublin, Irish Labour Party and Trade Union Congress.

[80] THE IRISH NATIONAL TEACHERS ORGANISATION. (1947). A Plan for Education. Dublin, INTO.

[81] COMMISSION ON HIGHER EDUCATION. (1967). Presentation and Summary of Report, Vol. 1. Dublin, Stationery Office.

[82] MARY IMMACULATE COLLEGE. College Prospectus 1976-77.

[83] O'CONNOR, D.C. (1971). Secondary Education in Ireland 1878-1968. M.A. Thesis, St Patrick's College, Maynooth.

[84] OECD. (1973). Classification of Educational Systems in OECD Member Countries: Austria, Ireland, Italy. Paris, OECD Publications.

[85] O'LEARY, P. (1962). The Development of Post-Primary Education in Eire since 1922, with special reference to Vocational Education. Ph.D. Thesis, Queen's University, Belfast.

[86] DEPARTMENT OF EDUCATION. Official Memoranda V13, V93, V95.

[87] MINISTER FOR EDUCATION. (1976). Address by the Minister for Education, Mr Richard Burke, T.D., on the occasion of the first meeting of the Governing Body of the Thomond College of Education. Typescript, issued by the Government Information Services.

[88] THE COUNCIL OF THE INSTITUTE OF MATHEMATICS AND ITS APPLICATIONS. (1978). Education in Schools: A Consultative Document (Cmnd 6869) Comments and Recommendations. *Bulletin of the Institute of Mathematics and its Applications*, 14, 34-38.

[89] BEGLE, E. (1970) (Editor). Mathematics Education: The Sixty-ninth Yearbook of the National Society for the Study of Education. Chicago, University of Chicago Press.

[90] THE INSTITUTE OF MATHEMATICS AND ITS APPLICATIONS. (1978). A Pilot Test of Basic Numeracy of Fourth and Fifth-year Secondary School Pupils undertaken by the Institute. *Bulletin of the Institute of Mathematics and its Applications*, 14, 83-86.

[91] BAJPAI, A.C. (1971). Service Teaching of Mathematics in Universities and Polytechnics. *Bulletin of the Institute of Mathematics and its Applications*, 7, 146-151.

[92] BAJPAI, A.C., MUSTOE, L.R. (1974). An Educational Philosophy for Scientists and Techologists using Computers. *International Journal of Mathematical Education in Science and Technology*, 5, 601-606.

[93] BRUNER, J.S. (1966). Toward a Theory of Instruction. Cambridge, Harvard University Press.

[94] JACKSON, K.F. (1975). The Art of Solving Problems. London, Heinemann.

[95] BRUNER, J.S., GOODNOW, J.J., AUSTIN, G.A. (1956). A Study of Thinking. New York, John Wiley & Sons.

[96] MILLER, G.A., GALANTER, E., PRIBRAM, K.H. (1960). Plans and the Structure of Behavior. New York, Holt, Rinehart and Winston, Inc.

[97] MAY, K.O. (1972). Teachers Should know *about* Mathematics. *International Journal of Mathematical Education in Science and Technology,* 3, 157-158.

[98] LIGHTHILL, J. (1976). The Interaction Between Mathematics and Society. *Bulletin of the Institute of Mathematics and its Applications,* 12, 288-299.

[99] BRAUNFELD, P., KAUFMAN, B. (1972). Mathematical Education-A Viewpoint. *International Journal of Mathematical Education in Science and Technology,* 3, 287-289.

[100] MERRITT, J.E. (1974). What Shall We Teach? London, Ward Lock Educational.

[101] AHLFORS, L.V. (1962). On the mathematics curriculum of the high school. *The Mathematics Teacher,* 55, 191-195.

[102] WILLOUGHBY, S.S. (1970). Issues in the Teaching of Mathematics. In, BEGLE, E. (Editor). Mathematics Education: The Sixty-ninth Yearbook of the National Society for the Study of Education. Chicago, University of Chicago Press.

[103] BAJPAI, A.C., MUSTOE, L.R., WALKER, D. (1975). Mathematical Education of engineers Part 1. A critical appraisal. *International Journal of Mathematical Education in Science and Technology,* 6, 361-380.

[104] GRIFFITHS, H.B., HOWSON, A.C. (1974). Mathematics: Society and Curricula. London, Cambridge University Press.

[105] NISS, M. (1977). The 'crisis' in mathematics instruction and a new teacher education at grammar school level. *International Journal of Mathematical Education in Science and Technology,* 8, 303-321.

[106] O'DONOGHUE, J. (1977). Mathematical Studies 1976-80 Cohort, Thomond College of Education. Unpublished.

[107] LONG, R.S., MELTZER, N.S., HILTON, P.J. (1970). Research in Mathematics Education. *Educational Studies in Mathematics,* 2, 446-468.

[108] POLYA, G. (1969). Fundamental Ideas and Objectives of Mathematical Education. In, Commonwealth Secretariat, Mathematics in Commonwealth Schools, London, Commonwealth Secretariat.

[109] BUCK, R.C. (1965). Goals for Mathematics instruction. *Mathematical Monthly*, 72, 949-954.

[110] FRASER, R.E. (1975). Computers in Mathematics. *International World of Computer Education*, 1, 13-18.

[111] KELLY, J. (1973). The Case for school computer courses. *Irish Times* 24 Sept. 1973.

[112] BRITISH COMPUTER SOCIETY. (1970). Computer Education for all. pamphlet, published by the British Computer Society.

[113] WIECHERS, G. (1974). Programming as an Educational Tool. *International Journal of Mathematical Education in Science and Technology*, 5, 699-703.

[114] GUNZENHAUSER, R. (1975). Computing in mathematics education. *International Journal of Mathematics Education in Science and Technology*, 6, 17-26.

[115] MORIGUTI, S. (1972). Some Thoughts on Computer Science Education in Japan. *International Journal of Mathematical Education in Science and Technology*, 3, 117-120.

[116] JACKSON, M., SMITH, B. (1974) Computer Appreciation Courses for Non-mathematical Students using an On-line Computer System. *International Journal of Mathematical Education in Science and Technology*, 5, 527-530.

[117] GREEN, D.R. (1977). Should the Mathematical Educator take the History of Mathematics More Seriously? *Bulletin of the Institute of Mathematics and its Applications*, 13, 91-95.

[118] WILDER, R.L. (1972). History in the Mathematics Curriculum: Its Status, Quality, and Function. *American Mathematical Monthly*, 79, 479-494.

[119] SCHAAF, W.L. (1963).(Editor). Our Mathematical Heritage. New York, Collier Books.

[120] KLINE, M. (1970). Logic versus Pedagogy. *American Mathematical Monthly*, 77, 264-282.

[121] JONES, P.S. (1957). The history of mathematics as a teaching tool. *The Mathematic s Teacher*, 50, 59-64.

[122] SELTMAN, M., SELTMAN, P.E.J. (1978). Growth processes and formal logic: Comments on history and mathematics regarded as combined educational tools. *International Journal of Mathematical Education in Science and Technology*, 9, 15-29.

[123] GRATTAN - GUINNESS, I. (1978). On the relevance of the history of mathematics to mathematical education. *International Journal of Mathematical Education in Science and Technology*, 9, 275-285.

[124] McLONE, R.R. (1971). On the Relationship between Curriculum, Teaching and Assessment of Mathematics. *International Journal of Mathematical Education in Science and Technology*, 2, 341-344.

[125] UCC COMMITTEE. (1977). Report of UCC Committee on the Application of Thomond College of Education (Limerick) to the NUI for Recognized College Status. Unpublished.

[126] KELLER, F.S. (1968). Goodbye, Teacher... *Journal of Applied Behavior Analysis*, 1, 79-89.

[127] SHERMAN, J.G. (1974). (Editor). PSI - 41 Germinal Papers. Menlo Park, California. W.A. Benjamin, Inc.

[128] ELTON, L.R.B., BOUD, D.J., NUTTAL, J. (1973). Teach Yourself paradigm: the Keller Plan Experiment at Surrey. *Chemistry in Britain*, 9, 164-168.

[129] BOUD, D.J., BRIDGE, W.A., MAAS, P., STACE, P.C. (1975). A potentiality of the Keller Plan in the transfer of courses. *Physics Education*, 10, 380-384.

[130] ROMISZOWSKI, A.J., BAJPAI, A.C., LEWIS, P.E. (1976). The Tutor's Role in the Individualisation of Service Courses in Mathematics. *Programmed Learning and Educational Technology*, 13, 59-68.

[131] STACE, B.C. (1976). Two Workshops on the Keller Plan: Content and Evaluation. *Programmed Learning and Educational Technology,* 13, 45-53.

[132] BAKER, L.J.V. (1974). Comparison of a lecture course with a Keller course in introductory psychology for university freshmen. *The Irish Journal of Psychology,* 3, 183-201.

[133] KULIK, J.A., JULIK, C.L., CARMICHAEL, K. (1974). The Keller Plan in Science Teaching. *Science,* 83, 379-383.

[134] KULIK, J.A., KULIK, C.L. (1975). Effectiveness of the Personalized System of Instruction. *Engineering Education,* 65, 228-231.

[135] TAVEGGIA, T.C. (1976). Personalized instruction: A summary of comparative research, 1967-1974. *American Journal of Physics,* 44, 1028-1033.

[136] HURSH, D.E. (1976). Personalized Systems of Instruction: What Do the Data Indicate? *Journal of Personalized Instruction,* 1, 99-105.

[137] BOUD, D.J., BRIDGE, W.A., WILLOUGHBY, L. (1975). P.S.I. Now - A Review of Progress and Problems. *British Journal of Educational Technology,* 6, 15-34.

[138] BAJPAI, A.C., PAKES, H.W., CLARKE, R.J.,DOUBLEDAY,J.M., STEVENS, T.J. (1972). FORTRAN AND ALGOL: A Programmed Course for Students of Science and Technology. London, John Wiley & Sons.

[139] GREEN, B.A. (1971). Physics Teaching by the Keller Plan at MIT. *American Journal of Physics,* 39, 764-775.

[140] YOUNG, D. (1973). Second Thoughts at Maryville. *Chemistry in Britain,* 9, 168-169.

[141] KELLER. F.S., SHERMAN, J.G. (1974). The Keller Plan Handbook: Essays on a Personalized System of Instruction. Menlo Park, California. W.A. Benjamin, Inc.

[142] THOMOND COLLEGE. (1977). Submission for Recognition of course as Degree Standard to University College, Cork. Unpublished.

[143] POLYA, G. (1948). How To Solve It: A New Aspect of Mathematical Method. Princeton, Princeton University Press.

[144] SCIENCE RESEARCH ASSOCIATES, INC. (1969). Computing Systems Fundamentals overview: A programmed instruction course. Chicago, Science Research Associates, Inc.

[145] PLOWMAN, P.D. (1971). Behavioral Objectives: Teacher Success Through Student Performance. Chicago, Science Research Associates, Inc.

[146] OSGOOD, C., SUCI, G., TANNENBAUM, P. (1957). The Measurement of Meaning. Urbana, University of Illinois Press.

[147] KERLINGER, F.N. (1973). Foundations of Behavioral Research. London, Holt, Rinehart and Winston. 2nd Edition.

[148] THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS. (1959). The Secondary Mathematics Curriculum: Report of the Secondary-School Curriculum Committee of the National Council of Teachers of Mathematics. *The Mathematics Teacher*, 52, 389-416.

[149] BONDI, H. (1975). Mathematics as an Education. *Bulletin of the Institute of Mathematics and its Applications*, 11, 2-5.

[150] MATTHEWS, G. (1976). Why teach mathematics to most children? *International Journal of Mathematical Education in Science and Technology*, 7, 253-255.

[151] THE ROYAL SOCIETY. (1976). The Training and Professional Life of Mathematics Teachers. London, The Royal Society.

[152] BRUNER, J.S. (1960). The Process of Education. Cambridge, Harvard University Press.

[153] BRUNER, J.S. (1974). The Relevance of Education. Hammondsworth, Penguin Education.

[154] SKILBECK, M., HARRIS, A. (1976). Culture, Ideology and Knowledge. Milton Keynes, The Open University Press.

[155] MANSFIELD, D.F., BRUCKHEIMER, M. (1965). Background to Set and Group Theory: Including Applications in the teaching of Mathematics. London, Chatto and Windus.

[156] SHULMAN, L. (1970). Psychology and Mathematics Education. In, BEGLE, E. (Editor). Mathematics Education: The Sixty-ninth Yearbook of the National Society for the Study of Education. Chicago, University of Chicago Press.

[157] WILDER, R.L. (1967). The Roll of the Axiomatic Method. *American Mathematical Monthly*, 74, 115-127

[158] WILDER, R.L. (1974). Evolution of Mathematical Concepts. London, Transworld Publishers Ltd.

[159] WILDER, R.L. (1972). The Nature of Modern Mathematics. In, LAMON, W.E. (Editor). Learning and The Nature of Mathematics. Chicago, Science Research Associates, Inc.

[160] KLINE, M. (1972). Mathematics in Western Culture. London, Penguin Books.

[161] BONDI, H. (1975). Education versus Training. *Bulletin of the Institute of Mathematics and its Applications*, 11, 114-116.

[162] BRUNER, J.S. (1971). The process of education revisited. *Phi Delta Kappan*, 53, 18-21.

[163] HIRST, K.E., RHODES, F. (1971). Conceptual Models in Mathematics: Sets, Logic and Probability. London, George Allen and Unwin.

[164] KENDALL, P.C. (1977). Mathematics and First Deadly Sin. *Bulletin of the Institute of Mathematics and its Applications*, 13, 124-128.

[165] LEE, D.H. (1972). Mathematics in the Community. *International Journal of Mathematical Education in Science and Technology*, 3, 159-168.

[166] FORD, B., HALL, G.G. (1970). Model-building - an Educational Philosophy for Applied Mathematics. *International Journal of Mathematical Education in Science and Technology*, 1, 77-83.

[167] LANCASTER, P. (1976). Mathematics: Models of the Real World. New Jersey, Prentice-Hall, Inc.

[168] BROWN, M. (1972). 'Real' Problems for Mathematics Teachers. *International Journal of Mathematical Education in Science and Technology,* 3, 223-226.

[169] BAJPAI, A.C., MUSTOE, L.R., WALKER, D. (1974). Engineering Mathematics. London, John Wiley & Sons.

[170] MATTHEWS, G., BAUSOR, J. (1972). Models and Measurement. *International Journal of Mathematical Education in Science and Technology,* 3, 275-279.

[171] DEPARTMENT OF EDUCATION AND SCIENCE. (1972). Teacher Education and Training: A Report by a Committee of Inquiry appointed by the Secretary of State for Education and Science, under the Chairmanship of Lord James of Rusholme. London, Her Majesty's Stationery Office.

[172] ORMELL, C.P. (1972). Mathematics, Applicable Versus Pure and Applied. *International Journal of Mathematical Education in Science and Technology,* 3, 125-131.

[173] OLLERENSHAW, K. (1977). Mathematics and Education - A Plan for the 1980's. *Bulletin of the Institute of Mathematics and its Applications,* 13, 146-153

[174] VESSALO, I.R. (1969) (Editor). The further training of mathematics teachers at secondary level. Hamburg, Unesco Institute for Education.

[175] FULLER, M.L. (1976). An Investigation into the Mathematical education of Business and Management undergraduate students. M.Sc. Thesis, Loughborough University of Technology.

[176] McDONALD, J.J. (1977). Introducing mathematical modelling to undergraduates. *International Journal of Mathematical Education in Science and Technology,* 8, 453-461.

[177] THE OPEN UNIVERSITY. (1977). Modelling By Mathematics, TM 281. Milton Keynes, The Open University Press.