Mathematics education issues in Ireland: special reference to appraisal

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MATHEMATICS EDUCATION ISSUES IN IRELAND:
SPECIAL REFERENCE TO APPRAISAL

By

JOSEPH ENGLISH BA MSc

A Doctoral Thesis

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

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

SCHOOL MATHEMATICS EDUCATION ISSUES IN IRELAND:

SPECIAL REFERENCE TO APPRAISAL

by

JOSEPH ENGLISH

CAMEET

(Centre for Advancement of Mathematical Education in Technology)

Loughborough University of Technology

As we approach the end of the 1980's, many issues face mathematics educators in the shadow of general unemployment and with inadequate resources. The teaching of mathematics, for example, is becoming increasingly complex and demanding. It is being greatly affected by increased demands for accountability from society and changing pedagogical possibilities with the onslaught of the microcomputer.

The focus of this study is on the identification, elaboration and analysis of key issues in mathematics education in Ireland, on which decisions will have to be made and to suggest possible responses together with probable implications. Many of these issues are not specific to Ireland. This study offers mathematics teachers, schools and ministries of education in other countries a useful rationale on key issues within which further debate and critical evaluation can take place in an organized fashion.
Major mathematics issues which emerge from the historical treatment of Chapter 2 are elaborated and analyzed in detail in Chapter 3. In Chapter 4, the author, a practising secondary school teacher, presents a pilot study on students' attitudes to schools, schooling and the mathematics courses which they are exposed to in his own school. A major focus of the thesis is contained in the subsequent four chapters. They focus on a key issue which the author felt was impinging on his classroom practice to a significant degree: the particular issue of the quality of mathematics teaching in schools and the need for teacher appraisal. This innovative work on appraisal includes the development of appraisal techniques designed specifically for mathematics teachers. The work culminates in the promulgation of a model for a national system of appraisal.

As appraisal is perceived to be a process and not an event, the evaluation approach employed was both qualitative and illuminative. Hence some triangulation of research methods was deemed appropriate to enable the differing experiences, perceptions and judgments of the innovative work to be captured. In particular, use is made of comments from 'critical academic friends'.

Chapters 9 and 10 are devoted to arguing and presenting the author's case for a new conception of the mathematics teacher as a self-empowered individual. Subsequent work must address and respond critically to key issues in school mathematics education if change is to be effected in the coming decade. In the concluding Chapter, the author makes some suggestions and indicates some areas for further research. Throughout the thesis, use is made of comparative material, especially from the U.K., in support of arguments and/or for description and amplification.
Key words: mathematics curriculum, students' attitudes, accountability, criteria for effective mathematics teaching, pedagogy, professional development, appraisal, empowerment.
ACKNOWLEDGEMENTS

The author wishes to acknowledge sources of encouragement, support and assistance received during the completion of this thesis.

As Director and Supervisor of the research, Professor A.C. Bajpai, OBE and Director of CAME~, has been a constant source of assistance, empathy, guidance and motivation. Generous and kind, his zeal and dedication has instilled in the author a new fervour for mathematics.

Dr. John O’Donoghue, Thomond College of Education, acted as Local Supervisor. He has been a continuous source of inspiration, guidance and support both morally and materially and enormously kind in his giving of time. His unrelenting enthusiasm and commitment towards advancing the cause of mathematical education in Ireland has left an indelible impression on the author.

The author wishes to express his gratitude for assistance given to him by the staffs of different libraries where he has worked and especially to John Devlin of the Library staff at Letterkenny Regional Technical College. The author also appreciates the generous use of school computer facilities during the draft phase of the thesis.

Sincere thanks and praise are due to the typists and proof-readers, both near and far, for their skill and patience, culminating in the high quality of the final manuscript.
Finally, my wife Brigid is deserving of a special mention. At all times her patience, good humour and moral support were always at hand helping to ensure the completion of the research work. This thesis is dedicated to my wife Brigid, daughter Joanne and our parents.
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CHAPTER 1
INTRODUCTION

1.1 Aim and scope of thesis

Educational issues have always commanded attention in the forefront of public debate. At the present time, as the end of the 1980's draws to a close, the situation has scarcely changed. In fact, for mathematics educators, the spotlight has increased in intensity on many key issues for a variety of reasons.

A highly significant contributory factor responsible for the increased focus on crucial mathematical education issues has been the onslaught of the technological revolution. It is unlikely that there is an educational system in the world that remains unaffected. Mathematics itself, for example, has been directly affected as new branches emerge and develop in response to an increasingly technological society. A further manifestation of the effect of this factor is evident in the changing balance of mathematical skills needed to function effectively in today's world. The actual pace of this information revolution is also another important consideration.

Along with the impact of modern technology, issues in mathematics education have been fueled and sustained by the changing expectations, demands and employment patterns within society. The serious and growing trend of unemployment would seem to indicate a need to reappraise the goal of 'compulsory mathematics for all'. Changing educational goals, syllabi and new structures are affecting the teaching of mathematics as are changing pedagogic possibilities, especially the advent of the microcomputer.
Regardless of what factors are the primary cause for bringing increasing attention and attempted responses to critical mathematical issues in recent times, it is essential that those people invested with the power to effect policy decisions in such areas of concern as educational philosophy, educational goals and structures and the content of the mathematics curriculum, will seek to understand and grasp thoroughly what these issues entail. Then, and only then, will their decisions be informed ones, thereby helping to contribute to the betterment of society.

As a practising mathematics teacher for the past six years in the Irish secondary school education system, the author has become acutely aware of a new state of flux in Irish education and the ensuing implications for secondary mathematics education at classroom level. The work now to be described is the embodiment of the author's experiences/researches during that period.

Specifically, the focus of this thesis is the identification, elaboration and analysis of key issues in mathematical education in Ireland as they relate to the secondary mathematics teacher. Naturally, there will be some overlap with general education issues. This is unavoidable and indeed necessary at times to ensure that the scenario is both complemented and complete. The major mathematical issues which emerge as significant for the secondary mathematics teacher in the Irish context are listed below without further comment for the present:

(1) the depowering nature and effect of the educational system at secondary level
(11) the present professional position of the secondary mathematics teacher
(111) students' attitudes to schools, schooling and mathematics at second level

1. Southern Ireland (Eire) should be understood by all such occurrences of the word "Ireland" in this thesis.
2. The term "Secondary" includes all types of post-primary schools viz. vocational, private secondary, community and comprehensive.
the aims, nature and content of the secondary mathematics curriculum
the role of the mathematics teacher in effecting change in a technological society
the effectiveness of the secondary mathematics teacher
accountability, appraisal and the secondary mathematics teacher

It is hoped that the analyses and syntheses go beyond mere description to provide new insights for secondary mathematics teachers. In so doing, the author suggests possible and apposite responses to these crucial mathematical issues together with highlighting probable implications for mathematics education. There is an element of immediacy to this task as decisions will soon have to be made on a number of key issues which confront mathematics educators.

There is also a positive 'knock-on' effect as this thesis can be articulated in a broader context. The issues which are subjected to scrutiny in this study are not specific to Ireland exclusively. This thesis offers schools, mathematics teachers, educational administrators and ministries of education in other countries a useful rationale within which further debate and critical analysis can take place in a cohesive and organized fashion. Thus, it is desired that the models, ideas and insights espoused together with the understandings which emerge from the innovative work will serve to illuminate the way ahead and stimulate dialogue for concerned mathematics educators worldwide. It is fair to say that such dialogue and debate, leading to increased awareness, is a necessary prerequisite for informed decision making as the arrival of the twenty-first century is ushered in. The study is thus both timely and opportune in this respect.

The question - Why research into issues in mathematical education?, might seem far removed from the secondary mathematics teacher whose context is the classroom and whose
job it is to teach. There are the daily demands of the academic curriculum, buttressed by the imperatives of public examinations. The answer is simply to improve the present position of the secondary mathematics teacher and the effectiveness of his/her teaching. It is expected that pupils will be the ultimate beneficiaries.

The above position is premised on the view that the present professional stance of the secondary mathematics teacher is unsatisfactory. The following precis (see Chapter 3 for more detail) leads one to conclude that all is not well, with much scope for improvement:

1. few teachers' centres and none specifically for mathematics
2. for the most part, he is an inactive and docile person working within hierarchical and authoritarian structures where meekness, obedience and subservience together with maintenance of the status quo are the order of the day
3. a restricted professional self-image of a subject specialist who prepares his pupils for examinations and this is reinforced by parental and pupil demands
4. no Teachers' Council exists which would enhance the professional image of mathematics teachers by assuming responsibility for the maintenance of professional standards
5. the mathematics curriculum is centrally prescribed with a lack of meaningful teacher participation in syllabus construction
6. virtually no opportunities or incentives for secondary mathematics teachers to engage in deliberative and innovative research work at national, local or school level
7. totally inadequate promotional opportunities - expertise in teaching is seen as having no impact on career prospects and consequently the activity of mathematics teaching has become downgraded
8. no mathematical advisers for teachers on a regular basis

3. The author is conscious of gender differences. However, from here on, the normal convention of "he" will be used throughout the thesis.
in-service training is underfunded, infrequent, voluntary and haphazard

pre-service training of mathematics teachers in general does not concern itself primarily with the pedagogy of mathematics - consequently there is a low premium put on the pedagogical knowledge and experiences which mathematics teachers can derive from their own classroom research

the years 1983 - 1988 have witnessed five years of unrelenting government cutbacks in post-primary education, which, when combined with voluntary redundancy, involuntary redeployment, an increase in teacher stress and discipline problems and the failure to provide the necessary resources for curricular and examination reform clearly indicate serious concern that the teaching profession and education in general are under siege.

This brief 'cook's tour' points to a highly unsatisfactory and an unenviable standing for the secondary mathematics teacher in Ireland.

As a practitioner belonging to this very group, the author has, over his six years teaching, experienced at first hand the disabling effect of these harsh and severe constraints. He is aware that he has realized only a small amount of the potential that is within him due to the curious manner in which the system has created and exerted a sense of impotence, even a loss of control over his own teaching process. He has experienced the strange but powerful peer group reaction to his sporadic attempts at innovating, both in his own classroom and school. To a large degree, many colleagues have agreed that getting by is good enough. He further realizes that he is part of a growing culture which believes that we ought to be able to explain ourselves. This has induced feelings of suspicion, even resistance towards change and the novel. More recently, he has become increasingly aware of the strongly held beliefs which parents hold regarding what should and should not go in a place called school. The growing demands and expectations of society in general, with an emphasis on making the mathematics teacher accountable for his classroom practice is further testimony to this consumer trend.
An immediate aim of this thesis is to raise the level of consciousness among mathematics teachers of what the system is doing to them in terms of control, morale and self-esteem. Furthermore, the crucial issue is the professional position of the secondary mathematics teacher and strategies and responses which aim to improve his present state. Only by deepening mathematics teachers' awareness of the issues and factors which shape their teaching and indeed their lives can their adverse professional position be improved. Only by such a thorough and fundamental examination and analysis will secondary school mathematics improve and in the process, more effectively serve the future needs of society. To this end, the author exhorts the reader to encourage secondary mathematics teachers to become more proactive, more self-empowered and, as a matter of urgency, to engage in an analysis of their own situation as a means of effecting an improvement.

That society has changed and continues to change is a well-established dictum and with it both the demands made upon mathematics teachers and also the technology that can be utilized in meeting those demands. The growing trend of accountability in all facets of society has been a significant factor in the surfacing of teacher appraisal as a major issue of concern. History tends to point to an inactive and/or reactionary response on the part of secondary mathematics teachers to issues of important concern. It is therefore fair to say that the introduction and operation of appraisal schemes is likely to take the form of an imposed decision by those in authority (who are often less qualified and less concerned) resulting in superiante and dictatorial appraisal for secondary mathematics teachers. The latter grouping in turn will be expected to cope with it in relation to their practice in the best possible way.

This thesis is the antithesis of a scenario which states that secondary mathematics teachers must remain passive and acquiescent individuals on whom yet further problems - in
this case, the imposition of a hierarchical system of teacher appraisal are to be unloaded. The view is taken that unless there is progress in developing an awareness of what appraisal could and should mean and in helping to promote a proactive and participative role for the mathematics teacher within that process, then there is a risk that appraisal will become another burden to be endured, that public funds will be traded for extravagance and that the state of secondary education will not culminate in an improvement. A publicly recognized and approved system of appraisal, it will be argued, provides a powerful vehicle by which a school organization can discharge its obligations of accountability; to the public and clients by maintaining and improving standards; to its staff by contributing significantly to staff and personal development; to its employers by overtly engaging in systematic self-appraisal monitored by an outside body.

The scenario described above is not specific to Ireland. In many countries there is a growing lack of confidence in the ability to teach mathematics successfully and an increased awareness in mathematical issues in general [1]. The perceived status of education has diminished. Apathy and crisis management must be avoided as acceptable interim solutions to the problem. In Ireland at present, the response has been marginal, confined to an academic debate on whether topic X or Y ought to be included in the syllabus for a particular year. This tinkering at a superficial level is an inadequate and unsatisfactory response. It appears certain, beyond reasonable doubt, that to avoid such a crisis of confidence will demand informed and active citizens, who in turn will require not just more mathematics but a greater understanding of mathematics. In order to deliver this requirement, there is a need for an improved mathematics teaching body, one which is competent, flexible and possesses an ability to respond and adapt quickly to cultural, social, economic and technological changes. It further assumes that these mathematics teachers are aware of the key issues and that they resist any tendencies to see
the problems of mathematics education as intractable. This poses a new challenge to all partners in the education system. It is not suggested that all the answers to the questions which arise from the debate are to be readily found in this study; rather, it is the author's intention that the views, experiences, syntheses and dialogue together with the suggestions and responses piloted will help to enlighten and illuminate the difficult and challenging path that lies ahead.

The thesis begins with an overview of the Irish education system together with an historical account of the mathematics curriculum and teaching at post-primary level. The latter is developed as a backdrop for the study. Major issues which emanate from the historical treatment of Chapter 2 are elaborated and analyzed in more detail in the succeeding Chapter. In Chapter 4, the author, a practicing secondary mathematics teacher, details a pilot study on pupils' attitudes to schools, schooling and the mathematics courses which they are exposed to in his own school. A major focus of the thesis is contained in the subsequent four chapters. They focus on a key issue which the author felt was impinging on his classroom practice to a significant degree: the particular issue of the quality and effectiveness of mathematics teaching in schools and the need for teacher appraisal. The innovative work on appraisal culminates in Chapters 7 and 8 where appraisal techniques, specifically designed for mathematics teachers, are presented for discussion together with a national model for the appraisal of secondary mathematics teachers. The models and ideas emerging from Chapters 7 and 8 are subjected to a limited amount of 'expert' scrutiny. The analyses and understandings which this study has generated led the author to produce a new conception of the secondary mathematics teacher as a self-empowered individual. The rationale for this notion is argued in Chapter 9 and in the penultimate Chapter the author elaborates and presents a profile of the self-empowered mathematics teacher. In the concluding Chapter, the author articulates his conclusions and
recommendations and suggests some areas for further research. The thesis is supported throughout with generous comparative material, especially from U.K. sources.

1.2 Methodology and evaluation

The research strategy is of an eclectic nature having elements of traditional experimental design, and a more recent approach, related to the methodology of social anthropology. The latter approach is both illuminative and qualitative, characterized by three significant features: it is holistic, inductive and naturalistic [2]. It is holistic in that an attempt is made to understand the global context in which the issues are set: there is an underlying assumption that an understanding of the situation as a whole is crucial for the interpretation of the data. A consequence of this is that initially at least, a heavy reliance is placed on qualitative methods rather than on standardized instruments. Closely allied to this is an inductive approach to the handling of data. That is, the dimensions of the analysis are not presupposed but, in as far as possible, are allowed to emerge in the course of the evaluation study. This approach was pioneered by Glaser and Strauss [3] who have provided useful guidelines. Thirdly, the approach is naturalistic: it does not attempt to impose an experimentalist framework on the process, but is flexible and responsive to a changing situation.

In the application of the evaluation approach outlined above, a range of research methods were employed in the collection of data. The use of multiple methods to study a single problem or issue is known as triangulation and is strongly recommended as a strategy in evaluation research [2]. The techniques adopted in this study include the use of questionnaires, semi-structured interviews, audio-recordings, classroom observations, group discussions with pupils, action-research and documentary research. As
appraisal (the analysis of which forms the cauldron of this thesis) is perceived to be a process and not an event, the above evaluation strategy was deemed to be appropriate to enable the differing experiences, perceptions and judgments of the innovative work to be captured and evaluated. In particular, use is made of comments from 'critical academic friends'.

Finally, perhaps there is no need to apologize, but to some extent this research strategy lacks the precision and objectivity demanded by those researchers reared on the positivist tradition. Apart from the reasons outlined above, the author feels justified in the utilization of the qualitative and illuminative approach for two reasons. Firstly, education is such a complex and value-laden enterprise that it would be presumptuous to assume that insights gained by other means are any less problematic. There are many examples in educational research to suggest that it is often those who seek objectivity who are in fact deluded. Secondly, the comments made together with the information and perceptions elicited are an integral part of the educational process. For example, the attempt to explore and identify the significance of pupil attitudes as an important area of concern in Chapter 4 involved semi-structured interviews and group discussions with pupils. This information was generated in an atmosphere of openness and mutual trust, where pupils were asked to assert, assess and articulate their educational experiences with regard to the teaching/learning nexus. Thus, the essential purpose of the methodological approach and evaluative strategy was to provide a mechanism by which proposed strategies, models and ideas together with problematic constructs could be evaluated, so as to generate creditable and serviceable insights and understandings and to reach conclusions where appropriate.
CHAPTER 2

MATHEMATICS IN IRISH SECONDARY SCHOOLS: AN HISTORICAL SURVEY

2.1 Introduction

Initially this Chapter presents a précis of the Irish educational system both as a matter of courtesy to the reader and to provide insight into factors contributing to the growth of the system today. The major part of the Chapter is devoted to an historical survey of developments in secondary school mathematics 1924-1988. In particular attention is focused on mathematics teaching.

2.2 The Irish education system: An overview.

It is not proposed in the following survey to provide a detailed and exhaustive account of the origins and complexities of the present day education system in Ireland. This has been achieved by a number of authors [4], [5] elsewhere. Rather it is the intent of the author to provide a thumbnail sketch initially of the present three-tier system. Salient characteristics, trends and features which contribute to the peculiar and complex nature of the education system are then identified and elaborated on in some detail. The sole purpose of this latter avenue of travel is to supply the reader with evidence of the special distinctive qualities belonging exclusively to the Irish system of education. Without such evidence, it is doubtful if credible insights can be gained into relevant present day issues. In conjunction with the historical treatment of secondary mathematics this scenario helps to inform the debate on issues in Irish mathematical education which follows in Chapter 3.
2.2.1 Irish education: a three tier system

The present system of Irish education can be divided into three levels for ease and coherence. Firstly, the third level system is a highly developed and complicated structure, comprising a university and a non-university sector. A Higher Education Authority exists which has statutory rights giving it power and responsibility over the entire third level sector. It is also the funding agency for the vast majority of institutions in this branch of education. Another important body is the National Council for Educational Awards which received statutory status in 1980. It represents the course-validating and award giving body for much of the non-university sector. This structure according to Coolahan [5] (p.252) is unlikely to be altered.

Secondly, second level or post-primary education consists of a junior cycle (age 12 to 15+) followed by a senior cycle (15 to 17+). Attendance at school is compulsory up to age 15. The state certificate examinations are normally taken after two years (Group Certificate), three years (Intermediate Certificate) and five years (Leaving Certificate). There are now plans to replace the Group and Intermediate Certificate examinations with a new Junior Certificate Examination to be taken for the first time in 1992 [6]. The existing system of examinations has remained largely unchanged since the amended Intermediate Act of 1924, two years after Ireland gained its independence. Post-primary education is administered, supervised and controlled by a Department of Education, set up in 1924 for this purpose. Capitation grants together with teachers' salaries are also provided by the state. Following the introduction of free post-primary education in 1967, pupil participation together with the number of secondary schools
increased dramatically. There now exists a variety of post-primary type schools: private secondary (which caters for about two-thirds of all second level students), community schools, comprehensive schools and vocational schools (which normally attract a greater percentage of less academically motivated pupils). The following table indicates the number of post-primary schools, teachers and pupils for the year 1987-88 classified according to type of school.

### Table 1: Statistics for post-primary schools 1987-88.

<table>
<thead>
<tr>
<th>Category of School</th>
<th>Number</th>
<th>No of Teachers</th>
<th>No of Pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Secondary Schools</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) under private lay management</td>
<td>22</td>
<td>282</td>
<td>4,782</td>
</tr>
<tr>
<td>(b) under Catholic religious</td>
<td>461</td>
<td>11,283</td>
<td>203,729</td>
</tr>
<tr>
<td>(c) under management of other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>religious denominations</td>
<td>22</td>
<td>395</td>
<td>7,107</td>
</tr>
<tr>
<td>2. Community Schools</td>
<td>45</td>
<td>1,814</td>
<td>30,455</td>
</tr>
<tr>
<td>3. Comprehensive Schools</td>
<td>16</td>
<td>528</td>
<td>8,941</td>
</tr>
<tr>
<td>4. Vocational Schools</td>
<td>253</td>
<td>5,395(^3)</td>
<td>83,182</td>
</tr>
</tbody>
</table>

1These figures relate to the school year 1987-88.
2These figures represent the number of teachers in receipt of incremental salary.
3This figure is the total of teaching staff allocations expressed in whole-time equivalent units, authorised in respect of full-time day courses conducted in Vocational Schools in the school year 1987-88.
4These figures relate to the 1986-87 school year.

Source: Dáil Reports, January 27, 1988
There are no selection tests for entry to community, comprehensive or vocational schools but some secondary schools do operate selection processes. The second level curriculum is centrally prescribed and controlled by the Department of Education. The management mode of each type of secondary school is summarized in Figure 1. In general, post-primary schools and the Department of Education provide a two-tier mechanism to ensure power, administration and control.

Finally, primary education is compulsory for all school-going children aged six to fifteen although many transfer from the age of twelve upwards to post-primary schools. Almost all schools in this sector are state-aided. The present primary school curriculum was introduced in 1971. The latter was underpinned by a child-centred ideology, which stressed the need to take children's needs and interests into account. The primary school curriculum is presently the subject of a major reappraisal by a review body under the auspices of the National Council for Curriculum and Assessment.1 The compartmentalised curriculum at post-primary level stands in sharp contrast to the methodological approach of primary education and this lack of alignment has contributed to transition problems. A significant administrative change in the management of national schools since the system was established in 1831 occurred in 1975, when management boards were instituted. This gave parents and teachers a degree of involvement for the first time with the patron's nominee (usually a clergyman appointed by the local Bishop).

Systematic inspections of primary schools are normally carried out every four or five years by the Department of Education's corps of inspectors from the primary branch.

Finally, the structure of the Irish education system is summarized in Figure 1.

1. This is a non-statutory council, established by the Department of Education in October 1987 to advise the Minister of Education on curricular and assessment matters at both primary and post-primary levels.
**Figure 1: The structure of the Irish education system**
2.2.2 Salient characteristics of the Irish education system

I The Church-State relationship

In general, since Ireland achieved its independence in 1922, the Church-State relationship has been characterized by the absence of confrontation on educational issues. Even though the methods whereby the State made financial aid available to privately-run denominational schooling changed dramatically in the 1920's, Coolahan [5] states clearly that the church clearly perceived the control of schooling as its privilege. The State chose to recognize the Catholic Church as a powerful partner in the education system and this stance was given legal recognition in Article 42 (clause 4) of the Constitution of Ireland, 1937 [5].

In practice, this 'acceptable' arrangement between Church and State had significant implications. It meant that the Church authorities owned and controlled the majority of second level institutions and furthermore, they were responsible for determining a catholic school ethos and the appointment of teachers. In return, the tacit agreement provided the Department of Education with important administrative and supervisory powers, especially in relation to examinations and the type of curricula taught. This state of affairs has persisted to the present day. Thus, Church and State represent a two tier system of control and power in second level education. The present structure and characteristics of Irish education owe much to this acquiescence. The highly regulatory school ethos of many existing private catholic post-primary schools can be attributed largely to the ownership rights of the Catholic Church, where teachers are
seen largely as the "hired hand". Over the years, it has virtually ensured that little or no progress has been made on the whole question of open principalships. As Kennedy puts it [7]: (p.5)

Who can justify 95% of principalships being held by religious while the total number of their incremental posts in the secondary sector is in the order of 16%.

This position is only now (1986) beginning to be open to all teachers as private secondary schools establish individual boards of management. It would be a mistake to underestimate the contribution which has been and indeed continues to be made by the religious in post-primary schools. Nevertheless, for the church authorities to deny their lay colleagues equal rights of promotion can hardly be perceived as a recipe for mutual trust. This lack of trust has also reared its head in the attempt since the mid-seventies to agree a redundancy and redeployment scheme for post-primary school teachers. It is difficult to estimate and to articulate clearly the effects of church ownership and the nature of its institutional ethos on the morale, enthusiasm and commitment of secondary school teachers. For example, the low level of participation in educational decision-making can be traced to a totally inadequate attempt by both Church and State to involve teachers closely in consultation or in the general administration of secondary schooling.

II The controlling role of the Department of Education

The Department of Education since its inception in June 1924 has exercised a predominant role in the control, supervision and administration of the Irish education system. The result has been a highly centralized system of education. Tussing [8], a perceptive external critic on Irish educational structure had this to say: (p.72)

The Irish system of education is perhaps the most centralized in Europe.
This control and influence is strongest at first and second level. At first level, the rules and regulations are determined by the Department of Education. Although democratization is apparent by the presence of management boards, teacher appointments are subject to the Minister's approval. The curriculum is drawn up by the Department which also sanctions textbooks. The regular systematic inspections of primary schools by Department inspectors provides an accountability mechanism to monitor teacher efficiency, school efficiency and the implementation of the curriculum in general. At second level, the curriculum is, for the most part, devised and prescribed by the State. The three public examinations are set and corrected by the Department. Ministerial approval is also required for teacher appointments. In contrast to primary schools, the monitoring role of the Department's inspectors at post-primary level is not preponderant. They visit schools less regularly and this traditionally low profile in the secondary sector has resulted in the absence of a vehicle for genuine accountability at school and teacher level.

The extremely centralized system at first and second level is reinforced by the absence of local education authorities which would administer the system at regional level. Attempts by the Department of Education to establish a professional and autonomous Teachers' Council have failed. The situation is further exacerbated by the fact that up until 1984, there existed no external consultative or advisory structure to view the totality of the curriculum or to advise the Minister of Education on questions of overall curricular balance. Indeed the power and control of the Department has been evidenced once again in the Department's refusal to grant independent statutory status to the interim Curriculum and Examinations Board which had been established in January 1984. The power base of the Department of Education with its supervisory and administrative functions has remained intact.
The centralized role of the Department has ensured a high degree of uniformity in the curriculum and in schooling practice in general. Admittedly, this can be attributed in part to the large number of Irish secondary schools which are relatively small in size and this has a limiting effect on the range and number of available subjects. Curricular uniformity has ensured the perpetuation of a curriculum dictated by the public examinations and one which is not responsive in general to the needs of society or indeed the majority of pupils [9]. The central control role of the Department has prevented any real delegation or autonomy for teachers, schools or other agencies to innovate in accordance with local needs. It is nevertheless interesting to note that schools are free to submit alternative syllabi for the Department’s approval on the understanding that the Department is not expected to provide examinations. This lack of validity from the Department for alternative syllabi, coupled with an inadequate support service for teachers and schools who might wish to become involved has, in practice, resulted in few schools submitting individual syllabi for ministerial approval. Nevertheless, the strengths of the centralized model, as Skilbeck [10] points out, should not be overlooked; it gives clear goal setting, clear role definition, equitable distribution of resources, impartial and external assessment and systemwide evaluation. However, the centralized system is under attack and there is growing support for decentralized systems with school-based curriculum decision-making [11].

The lack of consultation and participation in educational decision-making.

It is fair to say that both the Church and State have contributed to the failure to foster direct involvement in educational affairs by the public at large. Secondary schools and teachers have been largely responsible for implementing centrally determined rules and regulations together with changes and educational decisions over which they have had little or no input. It is true that since 1965, teachers are represented on syllabus review committees but few submissions
are received from the general teaching body — indeed the influence of the Department of Education as moderator is profound [12].

This deficiency in the education enterprise has been pointed out by Randles [13] as a major constraint which hindered the success of Irish educational reform measures during the 1960’s. School principals, teachers and other educational interest groups were not sufficiently involved in discussion and dialogue to fully grasp the implications of the new policy decisions. As a result, the effectiveness of the reforms was considerably reduced.

In 1980, the Department of Education admitted to the need for a review of consultative procedures on curricular matters [14]:

(p.48)

The fact remains that on questions of curriculum generally or of particular syllabi, there are no formal arrangements for consultation with industry or other branches of the economy, or with other institutions or groups within the community which might be regarded as having a legitimate interest in what goes on.

A broadly based Curriculum Council was proposed to include representatives of educational, cultural, commercial and agricultural interests whose task it would be to advise the Minister of Education on second level curricula and syllabi. This did not happen. However, in 1984, an interim Curriculum and Examinations Board (CEB) was established by the Minister. A new vision of the importance of consultation is evidenced from its terms of reference which included [15]:

In its examination of curriculum, the Board shall consult with appropriate individuals and organizations, and in particular with the representatives of teachers, school management, parents and the social partners.

The attempts to operationalise this consultative process can only be admired. It consisted of three main elements. Firstly, the public were invited to make written submissions
on various matters relating to education. Secondly, twenty-eight Designated Bodies were specified by the Minister to be consulted on major educational issues. Thirdly, the Board conducted a series of public meetings in October/November 1984 in a number of regional centres around the country. In due course almost a dozen consultative/discussion papers were published by the CEB to stimulate debate on curricular and assessment issues. This fresh approach represented a new departure in Irish education and the planned process of extensive consultation contributed to the refinement and development of the Board’s thinking on curricular and assessment issues. As laudable as these attempts were to increase broadly-based participation in the development, formulation and implementation of educational policy, it is questionable to what extent teachers at the school level comprehended and grasped the issues under review and the suggestions, views and recommendations which the Board had articulated. As Ryan puts it [16] : (p.13)

The documents circulated by the Board were called consultative documents but how can one consult with another who is basically ignorant, through no fault of their own, of what the documents are proposing.

This lack of awareness and ignorance by teachers in general can be attributed to the lack of a comprehensive in-service training programme to help teachers digest and understand what was being proposed. At another level, the responsibility to initiate meaningful discussion and debate on educational issues is clearly the prerogative of the school principal and senior school management. However, as the next section points out, management education does not have a privileged place in Irish post-primary schools.

IV The low level of management education in Irish post-primary schools.

Management of the education system in Ireland is centralized with decision-making in the hands of the Department of Education. The administration and supervision of post-primary education has always been the State’s privilege since 1924.
Consequently, the management task of post-primary schools is essentially to interpret and implement central policy directives. At no stage during the educational reforms of the 1960's was the case for management education in secondary schools advanced as a necessary prerequisite for successful innovation. Admittedly, management boards were set up in comprehensive and community schools but this attempt has been more notable for the jockeying for power by interested parties than for the quality of the debate concerning what constitutes good management.

The most striking feature of the Irish post-primary education scene, from a management perspective, is the complete lack of any formal management training at either pre-service or in-service level for those engaged in school management. This includes training for principals, vice-principals and post-holders. Vice-principals and post-holders in the vast majority of secondary schools are promoted on the basis of seniority. Consequently, the ill-effects of the Peter Principle are very much in evidence viz. people are promoted until they reach a job they cannot really manage [17]. Most post-holders do not have a real management function in their schools. Not only are all management appointments in secondary schools sanctioned without the prior benefit of any formal in-service training but no post-service training in management education is received while in the job.

The effects of this paucity of management training can be articulated at national and school level. Firstly, at national level, there exists a post-primary system of some 340,000 pupils, approximately 20,000 teachers [18], with an annual current budget of over five hundred million pounds [19]. Furthermore, the Chief Executive Officers of the Vocational Educational Committee's along with Department of Education officials have virtually no formal training in management education. This has culminated in a system which is underachieving and stagnant. It represents a serious deficiency in the context of the challenges facing Irish education at present. How can a system of education be developed to genuinely prepare young people for the world of
work when the very same system denies the possibility of serious consideration to management education as a vital process in secondary schools? Secondly, at school level, there are a number of serious shortcomings directly related to the lack of formal training in education management:

1. In the absence of training in management education, principals have failed to provide a coherent context in which dialogue and discussion can take place among staff, parents and pupils.
2. Relationships at school level have for the most part become frozen and formalized. Such an atmosphere breeds distrust, disunity, poor communication along with an isolated and introverted teaching body.
3. Due to inadequate information of management knowledge and skills, principals have failed in their responsibility to produce for staff, parents and pupils sets of management principles and aims on which school depends.
4. Such concepts as staff development, organizational "health" of the school and school-based curriculum development are conspicuous by their rarity in Irish post-primary schools.
5. An absence of in-school appraisal and review, combined with little or no action-planning for the future has perpetuated a tendency for schools to "carry on" as before, leaving weaknesses unremedied.
6. Staff meetings in general have become forums for information-giving and a mechanism for serving the administrative needs of the institution. Consequently, the potential of staff is seldom tapped and the renewal of staff personnel is not perceived to be significant.
7. Teachers in general have become inactive participants in a linear model of school management with little or no say in decision-making which affects their professional lives.
8. Those in management positions in schools are, in general, experiencing increasing pressure and stress with the lack of management structures. Nowhere has any real delegation occurred.

These effects are not just the embodiment of the author's own experience. They are articulated by colleagues informally in a variety of schools. Houston [20], a practising secondary

*Education management and management education have been treated as synonymous in the context of this thesis.
school teacher, had this to say when evaluating the introduction of a remedial education unit into a traditional and religious-run Irish secondary school: (p.62)

The introduction of remedial education represents a distinctive sub-culture with distinctive practices and values which are incompatible with many features of the dominant culture. Remedial education transgresses subject boundaries, calls for new team approaches and demands a response in institutional ethos. In many respects, it served to decorate and compensate the old traditional reality while many of the essential educational qualities underpinning the innovation were fundamentally discarded. (The author’s italics)

The situation has improved somewhat in recent years with the provision of a number of courses in management education, both by the Department of Education, the Secretariat for Secondary Schools and the Vocational Educational Committees (VEC’s). The Marino Curriculum Service, launched in 1986 by the Christian Brothers, aware of the need for training in management education, is willing to provide seminars in schools on request to encourage self-reflection and skill building along with helping schools formulate an educational philosophy, jointly negotiated among parents, management authorities, staff and students.

However, Irish secondary schools in general continue to remain undermanaged. The school management mode approximates to a day-to-day maintenance operation. Its features, for the most part, include elements of a "top-down", linear and mechanistic approach within hierarchical structures. Secondary school principals have failed to give their staff vision and ability to perform. Genuine delegation is rare. This inability or reluctance to take management education seriously has resulted in the absence of modern educational management knowledge and skills in Irish educational theory and practice and thus the effectiveness of schools has been considerably reduced. Indeed, the greater problem may be the inability to appreciate the importance of management education and the fear that so long as the education system is managed from the centre, management criteria will not be applied and political expediency will continue to prevail in matters that deserve
more enlightened understanding. Although the Department of Education has indicated its recognition of and commitment to management education [14], [21], realistic action-steps have not been implemented. Recent initiatives in Irish education have concentrated on structure, curricula and examination changes. However, no setting up of workable structures nor any amount of educational knowledge and experience will prove effective without management skills appropriate to the job on hand. The changes taking place in Irish education cannot wait so long and serious reappraisal of management skills at post-primary level is of the utmost importance.

2.2.3 Recent developments in Irish post-primary education

The 1980's have been remarkable if only for the wide range of reports on so many aspects of educational provision including future planning policy, in-service education, discipline, curriculum and assessment and regional educational structures. Although the attempts to implement recommendations have been sporadic due to financial constraints, it nevertheless reflects the amount of investigation and appraisal which was undertaken. The government's long-term thinking on education was set out in the long-awaited White Paper in 1980 [14]. However, in common with the Programme for Action in Education 1984 – 87 [21], little or no action was taken to implement the various recommendations. Undoubtedly, the most significant educational innovation introduced was the establishment in 1984 of an interim Curriculum and Examinations Board (CEB). Attention is now turned to this development.

The pioneering and effectiveness of reforms by the Department of Education depends on the political will of the Government and the support and leadership of the Minister in power at a particular time. In this respect, the Minister of Education in 1981 - Mr. Boland - must be given credit for his initiative and imagination in proposing the establishment of a broadly based Curriculum Advisory Council. However, it was not until 1984 that this idea was realized in the setting up of an
interim Curriculum and Examinations Board (CEB) to assess the relevance of the curriculum and the function and effectiveness of the examination system [15]. On a positive note, the CEB did put forward a number of significant proposals which mark a watershed in Irish education. The Board called for the replacement of the Intermediate and Group Certificate examinations with a unified system of assessment at junior cycle level, which would broaden the scope and range of skills and qualities assessed. Plans are currently being made to press ahead with the introduction of the new examination in 1992, which will become known as the Junior Certificate Examination [22]. The CEB also proposed that teachers be involved in the assessment of their pupils as part of their professional work. Furthermore, the CEB emphasized the need to introduce flexible structures which would allow local needs to be taken into account in the development of new courses [23], [24]. The emphasis on localization, teacher involvement, flexibility and consultation stands in sharp contrast to features which have characterized the Department of Education for so long viz. prescription, central control and uniformity.

However, what has not emerged is clear evidence that principals and teachers are prepared to adopt a new professional perspective and orientation to their work which is crucial to the success of the proposed reforms. What the CEB did do was to stimulate and move the debate on curriculum and examinations onwards. Through its many consultative discussion documents, it encouraged fundamental scrutiny and evaluation of the curriculum. It helped establish priorities, a framework, an action plan within which all partners in the education enterprise could contribute. However, the attempts of the interim CEB to translate discussions, submissions and proposals into action plans to benefit young people were hampered by the failure of the Department of Education to grant it statutory status. This reluctance to delegate power and control to the interim Board demonstrates the overriding and dominating influence which the Department of Education
exerts on Irish educational affairs. It is clear that the CEB had completed much of its work but to implement its recommendations would have required a massive injection of finance to fund in-service education, a reduction in the pupil-teacher ratio and extensive resources. This implication represented the antithesis of what government policy in education was trying to achieve - widespread cutbacks, as part of the national plan for economic recovery.

In October 1987, the Minister of Education announced the reconstitution of the CEB as a non-statutory advisory council for curriculum and assessment. The new council became known as the National Council for Curriculum and Assessment (NCCA). Its primary function is to advise the Minister of Education directly on all matters related to curriculum and assessment at primary and post-primary level. Part of the new Council's brief is to examine in particular the junior cycle of post-primary schooling and to come up with a revised curriculum for students entering secondary school in 1989, in anticipation of the new Junior Certificate to be introduced in 1992. A related Review Body has also been appointed to examine the primary school curriculum. In addition, the Council is to revise the Rules and Programme for Secondary Schools - the booklet which prescribes rules, regulations and syllabi for all secondary schools [25].

Another trend which emerges in this period is the move towards regionalization of education structures. The Programme for Action in Education 1984 - 1987 [21] suggested that local Coordination Committees be established. It also recognized the need for regional education structures and proposed the establishment, in the voluntary secondary school sector, of county associations of school principals broadly in parallel with Vocational Educational Committee administrative districts. This line of thinking culminated in the eventual publishing of a Green Paper - Partners in Education, Serving Community Needs [26] in 1985. Significantly, it proposed the establishment of thirteen Local Education Councils (LEC's) to oversee educational and other services on a local or regional basis. Implied in this suggestion was the rationalization of
the various post-primary schools together with the reconstitution of the thirty-eight Vocational Educational Committees. However, these reforms never received legislative status.

That a climate of economic scrutiny and accountability prevails at present in Irish education is evidenced from the series of unrelenting cutbacks which have been levied on post-primary education in the years 1983-1988:

- the pupil-teacher ratio has been fixed at 20:1 - this is particularly severe on schools in the Vocational sector who up to this have had a preferential ratio.
- schools with less than 500 pupils have lost their ex-quota career guidance teacher
- vice-principals have been included in the quota
- £200 is being extracted to repeat the Leaving Certificate
- school transport charges have been introduced
- spending on in-service training continues to be provided at totally inadequate levels.

These cutbacks have resulted in larger classes, reduced curriculum options, curtailment of specialist services and these constitute impediments to positive curriculum development. Ironically, this trend of economic scrutiny gave rise to the development of pressure groups. Firstly, it is possible to discern a new degree of cooperation among the three teacher unions who traded under the banner "Teachers-United" in the early 1980's in an attempt to secure salary increases. This move succeeded in the attainment of almost all their demands. Secondly, there has been a remarkable increase in the involvement of parents in educational affairs. With the establishment of a National Parents' Council (NPC) in 1985 and the heightened awareness among parents in general which this has brought about, a new and highly articulate force manifests itself within the educational arena. This parental power was harnessed by the Primary Teachers' union in 1987 in their campaign to reverse the primary education cuts which proposed larger classes and the loss of teacher jobs. The passionate and vociferous outcry of parents contributed significantly to the suspension of the cutbacks and to the
government's readiness to seek to resolve the issue. Eventually, in April 1988, an agreement was reached which considerably reduced the severity of the cutback measures. Thus, the parental body suggests enormous latent power which can be utilized to prevent serious loss of quality to the provision of educational services. Against this, there are realistic fears among teachers that the potential power of parents can be a two-edged sword, a smoldering volcano, and that the kind of pressure which they can bring to bear on teachers may result from a very partial vision of classroom needs as a whole. Such undue pressure could seriously undermine the already low morale of teachers. On the other hand, it seems reasonable that, given the high level of education and organization among parents, they should have a say and should contribute to educational debate. The challenge is to find the proper channel that avoids unwarranted intrusion into the sphere of the professional, but provides an adequate hearing for constructive opinion. Recently, the NPC has demanded "parent-power" in the education system together with parent education programmes [27].

However, it was stated by the NPC that such attempts were not intended to intrude on the professional path of teachers, rather the intention was to build a partnership in which the roles of teachers and parents complemented each other [27]. Finally, recent years have also witnessed, for the first time, an alliance of parents, secondary school managerial authorities and teachers. Formed in 1987, this grouping became known as Partners for Education and was forged in an effort to defend the education service from shortsighted cutbacks and to highlight the achievements of Irish education which it was felt were being undermined. Not all the aims of Partners for Education were achieved; nevertheless, the unprecedented level of activity and cooperation throughout the country has ensured that politicians have a much greater appreciation of the size of the constituency they must deal with if they are to further
worsen the educational provision. This alliance can hardly be accused of being a narrow pressure group, as it represents the broad mass of Irish people in the pursuit of improved educational facilities.

The tendency towards cutbacks in educational expenditure is an indication that the potential significance of education is diminishing in the eyes of the Irish government. However, despite the changes in society which have affected attitudes to schooling and despite the deficiencies of the present education system, formal schooling is held in high regard in general. Academic education and qualifications are still a major priority among parents and employers. This has exacerbated the present situation in the sense that pupils compete for examination success and academic distinction while youth unemployment continues to remain a serious trend.

This brief survey of Irish education has pointed towards a new sense of excitement in the early 1980's. However, this state of flux has subsided somewhat in the latter part of the decade as more mundane issues rise to the forefront of educational debate. Such matters include the negotiation and implementation of early retirement and redeployment schemes, the improvement of conditions for temporary teachers and improved resources and support services for teachers. The inability of the CEB and later the NCCA to match its rhetoric with performance in reality has left schools and teachers looking somewhat askance at their commitment. It is for this very reason that teacher unions are unlikely to greet new initiatives with enthusiasm. Nevertheless, the NCCA, with its announcement in March 1988 of a new junior cycle course in technology to be examined in 1992 as part of the new Junior Certificate examination, is addressing a crucial question now facing the Irish post-primary sector: how to assimilate into schools the most radical force for change that now pervades everyday life - technology. The response to this challenge will have to contend with the fact that the present value orientations of many traditional Irish post-primary schools and its teachers neither encourage nor promote initiative and enterprise [28]. The existing system of education may well be
excellent in itself but it has not made any attempt to be relevant to the day-to-day needs of Irish society. Fundamental questions as to the purposes of schooling in this late twentieth century for a generation of young people who will belong to the twenty-first century and how the school curriculum and assessment procedures should respond in terms of student need in the areas of learning, knowledge, experience, attitudes and values remain as formidable challenges for Irish education in the future. However, recent government policy has ensured that positive attitudes, teacher morale and goodwill, optimism and confidence which are all so necessary for genuine educational progress and curricular reform will not be available in large amounts.

2.3 Secondary school mathematics in Ireland 1924 - 1988

2.3.1 Developments in the years 1924 - 1960

When the new independent Irish free state formally inherited the administration of the educational services in 1922, it signalled the drawing to an end of post-primary (or Intermediate education as it was then known) education under the control of the Intermediate Education Board, which had legislative powers since the passing of the Intermediate Education Act in 1878. With the dissolving of the Board in 1923, the Department of Education was established in June 1924 and secondary education came under its administration. This event was given statutory status with the passing of the Intermediate Education (Amendment) Act in the same year. Under this act, certain fundamental changes in the examination system and in the programmes of instruction were permitted. The Junior, Middle and Senior grades were replaced by the Intermediate and Leaving Certificate Examination, a framework which has persisted ever since for secondary education. Indeed the programme of instruction for mathematics adopted in 1924 remained in force with only a minor modification until it was replaced by the new mathematics curriculum in 1964. To inform and prepare for the fundamental changes which the
new Irish government envisaged for education, the Irish government appointed a commission on Secondary Education in 1921 to "draft a programme which would meet the national requirements while allotting its due place to the Irish language" [5]. This commission culminated in the production of a number of subject committee reports and collectively many of its recommendations formed the basis of the programme for secondary schools which first came into operation in 1924. Significantly teachers were accorded full representation on the commission which included the participation of trade unions, interested individuals and groups. It is appropriate to look briefly at what considerations formed the basis for the drawing up of the mathematics programme. This was the responsibility of the mathematics subject committee. The subject committee in the carrying out of its task had to take cognizance of the fact that schools and teachers were free to draw up their own programme (subject to Department of Education sanction) and that uniform texts would not be prescribed. Two courses in mathematics were recommended for the Senior Leaving Certificate and the compulsion of mathematics at Junior level was also proposed. Arithmetic, geometry and algebra formed the three content areas for the curriculum. The process by which these recommendations were made were accompanied by a number of significant features [29]:

(1) the members of the commission specified general aims in the teaching of mathematics and the time needed to achieve these aims

(II) the needs of students who were expected to benefit from the new courses were identified

(III) teachers, headmasters, university professors and others with wide experience of education had a significant influence in the construction of the courses through a consultative process.

These guidelines have not been evident to the same degree in any major innovation in mathematics since.

Although the commission concluded its work in 1922 immediate action to implement the recommended new programmes was not taken until 1924. However, this did not prevent the publication of pamphlets [30] designed to help mathematics
teachers. These outlined the aims of the course, criticized repetitive techniques, advised teachers on preferred teaching methods and encouraged teachers to explore different approaches.

The new programme which finally appeared in 1924 contained some alterations from the recommendations of the commission. Two courses - A and B were offered at both Intermediate and Leaving Certificate level. The Pass Leaving Certificate course was an extension of the Intermediate course with additional elements in algebra, arithmetic and geometry. The Honours course at Leaving Certificate level represented an ambitious approach which challenged both teacher and pupil and formed the basis for the examination at this level for the next forty years. The time allocation in the mathematics papers was weighted in favour of algebra and geometry. Despite discontent and protestations from a number of sources including teachers, the examinations of 1925 and subsequent years at both Intermediate and Leaving Certificate levels proceeded with uniformity. To obtain a pass in the Intermediate Certificate examination a pupil was required to pass five subjects, in which the following were compulsory:

1. Irish or English
2. A second language
3. Mathematics or alternatively for girls only arithmetic with any one of Science, Domestic Science, Drawing or Music.
4. History and Geography

To obtain a pass in the Leaving Certificate examination a pupil had to pass in five subjects, one of which had to be either Irish or English.

Following an appraisal of the secondary school curriculum in 1937, no significant curricular changes were instituted except that set syllabi and prescribed textbooks were reintroduced for secondary school subjects between 1939 and 1941. Courses were shortened as it was felt that existing programmes were too extensive and vague [5]. Another review of the secondary school curriculum was undertaken by the Council of Education
in 1954 [31]. When its report was eventually published in 1962 it did not cause a stir among those who anticipated a reform of the system. It endorsed the grammar school curriculum which prevailed.

Thus, the period from 1940 - 1960 represented a time of stability in the history of mathematics at post-primary level. Mathematics teaching was rarely coordinated with science teaching and consequently the approach to mathematics was extremely academic. Some development of the teaching profession is evident in retrospect. In 1924-1925 incremental salary scales were paid to teachers after a registration council for teachers came into operation in 1918. In 1929, a superannuation scheme was conceded to teachers and this was followed in 1937 with the granting of a contract of employment with right of appeal. In the early sixties, an attempt to attract mathematics teachers into secondary education met with little success. The promotion of an Irish culture was very much a priority in these early years. The first Minister of Education said in the Dáil, November 1925 [32]:

The business and main function of the Department of Education in this country are to conserve and build up our nationality.

During the period under consideration the post-primary mathematics teacher would have experienced a school ethos characterized by its narrowness, insularity and nationalistic orientation. As Akenson [33] puts it, one: (p.60)

where church and state combined to confine the outlook of teachers and pupils, where the school curriculum was designed to serve a political purpose and where there was an apparent lack of concern for the development of individual children in the school as children, rather than as digits in the Irish revival.

Thus, it is difficult to imagine mathematics teachers, restricted by such a stereotyped and introverted climate, presenting a proactive and dynamic model to their students.
Involvement of mathematics teachers in matters of syllabus development was non-existent. However, the reforms of the sixties were to change the attitude of teachers in relation to curriculum development together with the introduction of new programmes of instruction.

2.3.2 The reforms of the 1960's

The reform measures introduced in the sixties were closely linked to economic considerations. One indication of this was the launching by the Irish government of its Second Programme for Economic Expansion in 1963 to cover the period 1964 - 1970. In it the Government envisaged education as having a significant role to play. The Programme devoted a specific chapter to education which referred to the need for greater participation in education, the restructuring of post-primary school provision and curricular changes, particularly in mathematics, science and modern languages [34].

This overt linking of the quality and nature of the education system with economic development was also apparent in the work of the survey team set up jointly by the Organization for Economic Cooperation (OECD) and the government in 1962 to effect an analytical appraisal of the education system. When it reported in 1965, the Investment in Education report [35] contained a section dealing with the curricula in operation in the schools. Concern was expressed at the relative lack of success at honours level in mathematics and science. It was noted that only forty four per cent of the instruction in mathematics was given by the teachers who had mathematics in their degree and sixty four per cent of science teaching was conducted by non-science graduates. From investigations made by the survey team, it was concluded that mathematics teaching in vocational schools was generally conducted by non-specialists [35].

In general, education was perceived as an economic investment comparable with interest in capital plant [34]. Ireland's increasing links with international organizations also influenced attitudinal change. Ireland was represented at
international conferences and symposia on educational affairs which helped to reduce the insularity and introverted attitude of previous decades. With the help of Irish Teacher projects, Irish teachers were afforded the opportunity to participate in organized educational visits to Europe and America. International influences thus affected educational developments in Ireland and it is against this background of wider social and attitudinal change that curriculum development in secondary mathematics occurred.

Even before the publication of the two aforementioned reports, a number of events had already taken place, both in the United States and Europe which were significantly shaping the nature of curricular change in secondary school mathematics in the early sixties. The European influence can be traced effectively to 1959 when the Department of Education sent a representative to the OECD conference *New Thinking in School Mathematics* [36]. Sweeping changes were recommended for secondary school mathematics curricula. In 1960, the Department’s Chief Inspector, Mr. Sean Close, visited the U.S.A. and whilst attending summer training sessions at New Brunswick and New Jersey perceived a need for the introduction of changes in Irish post-primary mathematics [37]. In the U.S.A. the major impetus for change in mathematical education came from the launching of the first Sputnik by Russia in 1957. The latter had a huge effect on American complacency about their undoubted engineering capacity and its superiority over that of the Russians. Funds were pumped into education, especially to improve its scientific and mathematical quality. On the advice of the Chief Inspector’s report, Ireland responded by sending three teachers and an inspector to the United States in 1961 to attend training courses in the "new

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2. The author is grateful to Mr. Fred Holland, secondary mathematics teacher for supplying much of the detail in this section by way of private correspondence in May, 1985. Mr. Holland was one of the three teachers who visited the U.S.A. to look at developments in secondary school mathematics.
mathematics". They also visited education departments in the states of New York, New Jersey and Philadelphia. The new material presented included modern algebra, sets, relations, functions, probability with statistics and also number theory with an emphasis on new approaches to old topics. On their return to Ireland, Inspector Nolan and Fred Holland wrote to the Department of Education giving their observations on new developments in secondary mathematics. They made suggestions for new mathematics curricula and appropriate methods of teacher training. The suggestions were adopted. However, the Department of Education, in accepting their recommendations, deemed that teachers were not ready for the new material and decided to start the new curricula at Leaving Certificate level and to train the teachers concerned. The hope was that when these teachers had become acquainted with the new material they in turn would train Intermediate Certificate teachers in the new curricula. In addition, a smaller number of teachers would be involved at the Leaving Certificate level and they were likely to be more highly qualified mathematically. The first courses were eventually introduced at Leaving Certificate level in 1964 for examination in 1966. Changes in the Intermediate Certificate course were to follow later in 1966 for examination in 1969. The examination format changed with the introduction of the new courses. Instead of examining arithmetic, algebra and geometry separately as was formerly the case, the new examination papers were 'integrated'. Students were required to answer six questions from a choice of ten in both mathematics papers, which promoted a 'question-spotting' approach to teaching.

The new Intermediate course also contained some of the new material introduced into the Leaving Certificate course. This in turn forced changes in the Leaving Certificate course which took effect in 1969. Following this, both courses were subjected to revision in the seventies. It is a matter of importance to note that while the first new courses were drawn up by the Department of Education in consultation with University representatives, all later changes referred to above were the result of the work of syllabus committees introduced for this purpose in 1965. These committees still
exist to the present and comprise representatives from the Department of Education, school management bodies, teachers’ unions, universities and a representative from the Irish Mathematics Teachers’ Association. In practice, all the managerial and teacher union representatives are usually mathematics teachers; thus the committees do have an input from practitioners at school level. These committees also examine submissions sent in by bodies and individuals but in reality few submissions are made by the general body of mathematics teachers.

Up to this time the mathematics syllabi had been stagnant and syllabus renewal was for the most part unheard of. There existed a notion that almost anybody could teach mathematics. There was an over-emphasis placed on mechanical methods, computation in algebra and arithmetic had become complicated. The manner in which geometry was taught and learned was deficient. Often problems given to students were artificial and not related to everyday life. From this viewpoint, it is fair to say that a certain readiness for change existed at the time the new courses were launched.

The reform measures were an attempt to recast school syllabi so as to bring them into harmony with the methods and spirit of modern thinking in mathematics. The following reasons have been advanced for the sweeping changes which give an indication of the philosophy inherent behind the introduction of the “new mathematics” [38]:

(1) School mathematics should be redesigned and restructured to serve more directly the needs of a future technological society.
(II) Greater emphasis should be placed on meaningful conceptual learning of the subject.
(III) Artificial distinctions between different branches of mathematics should be broken down and the unity of the subject more clearly displayed.
(IV) Students should become more aware of and learn to appreciate the modern emphasis on structure.
(V) The need to prune existing traditional syllabi in order to accommodate the accelerated expansion of mathematical knowledge.
2.3.3 Opposition to the new courses

Although a certain state of readiness and excitement existed at the time the new mathematics courses were launched, this is not to say that the new courses were ushered in without resistance. When the Department of Education in early 1963 announced that they were ready to introduce major changes in the Leaving Certificate mathematics and science programmes in the following September for examination in 1965, it provoked objections from teacher unions. For example, the Central Executive Committee (CEC) of the Association of Secondary School Teachers of Ireland (ASTI) on 19 April formally objected to this inadequate notice and its mathematics sub-committee took a very strong line on this issue insisting that [39]: (p.254)

before finalizing and introducing the proposed new courses, the ASTI be consulted and its views considered as to the content and time of implementation.

As a result of the meeting, a joint deputation met the Minister of Education on 29 May at which the teacher representatives pressed for the postponement of the introduction of the new courses for a year as well as for the satisfactory provision of textbooks and refresher courses. As Coolahan remarks however [39]: (p.254)

No real satisfaction on these issues was gained at this meeting but a series of other meetings and deputations took place which resulted in postponing the examinations in the new courses to 1966 instead of 1965.

It is important to point out that apart from this action by ASTI there followed a comparatively smooth transition to the "new mathematics" which was ironically due entirely to the cooperation between the Department of Education and the Irish Mathematics Teachers' Association (IMTA). The joint
endeavours of the Departmental staff and the teachers proved to be very satisfactory [37].

In summary, the initiative to introduce the new courses came from the Department of Education, following in the long tradition of central determination of syllabuses. However, teachers did have an input into the new changes which increased with the advent of the syllabus committees in 1965. Industry did not contribute in any way to the debate. In conjunction with teacher organizations and particularly the IMTA, the Department of Education directed and financed the input of teachers. In order that the necessary reforms in mathematics education should have any chance of being carried through successfully, a massive programme of teacher training and retraining was necessary. This need was in fact realized at the time the reforms were discussed and planned [37]. Attention is now turned to how this objective was realized in Ireland and here the role of the IMTA was very much in evidence.

2.3.4 Teacher training in the new mathematics curricula.

In September 1961, immediately after coming from the United States, Fred Holland organized a mathematical circle for secondary teachers in Cork [37]. In January 1964, a national society called the Irish Mathematics Teachers' Association (IMTA) was formed at a meeting in Newman House, Dublin. Mr. Denis Buckely of the ASTI became the first President of the IMTA. Among the distinguished mathematics teachers present at the inaugural meeting were President de Valera and Professor Lancos of the Institute of Advanced Studies. The Cork circle amalgamated with the IMTA.
Fred Holland in a recent correspondence remarked that [37] :

The IMTA and its members were to play the major role in the implementation of teacher training in the New Mathematics.

Firstly, the Universities in Dublin, Cork and Galway led the way in teacher training. The new curricula had already been published when the first Summer School Course was held in July 1963 in University College Dublin (UCD). This was followed that same summer by a course in University College Cork. Later in August 1963, the Department of Education organized a nationwide course in UCD which was attended by over five hundred teachers from all over Ireland. Six lecturers from UCD, Trinity College and University College Galway together with Fred Holland gave the lectures. As the new courses were to be introduced at Leaving Certificate level it was mathematics teachers who taught the subject at this level who were trained first in the hope that they in turn would pass on their knowledge and skills to Intermediate Certificate mathematics teachers. The winter months of 1963-1965 saw much in-service training organized by the IMTA. In 1966, when much of the new Leaving Certificate material was transferred to Intermediate Certificate level, the teacher training was achieved by both the Department and the IMTA. Teachers of Leaving Certificate mathematics gave the new courses to Intermediate Certificate teachers at the summer in-service training sessions [37].

As noted earlier, a comparatively smooth transition accompanied the introduction of the new mathematics courses by the collaborative efforts of the Department and the IMTA - a co-operation which was new in the experience of secondary school teachers in 1960. Reforms initiated by centralized Ministries of education (such as exists in Ireland) commit those Ministries involved to an extensive in-service training programme. Merely changing the syllabus and textbooks is insufficient to bring about curriculum development, as the average teacher has a very great capacity for continuing to do the same thing under a different name. The toughest part of any development work is the in-service
training stage and in this respect great credit is due to the Department of Education, who in conjunction with the IMTA ensured a much more satisfactory reform of the mathematics curriculum [39].

2.3.5 Further changes and teacher disillusionment

With a commitment by the mathematics syllabus committee to revise courses on a regular basis, a slightly changed version of the Intermediate Certificate mathematics course was introduced in 1973 for examination in 1976. Subsequently, in order to accommodate these changes, an amended Leaving Certificate mathematics course was introduced in 1976 for examination from 1978 onwards. The changes introduced were not as far reaching as those of the earlier reforms. Geometry for example, in the updated version of the Intermediate course concentrated solely on transformation geometry whereas the earlier changes had combined the traditional Euclidean approach with a flexibility which included some transformation geometry in the Papy style [37]. This streamline of the geometry section proved to be a most controversial topic, but as teachers' complaints were not adequately co-ordinated, the new modifications were implemented [40]. Changes in the Leaving Certificate course were less significant but the format of the examinations changed. Each of the two Leaving Certificate papers incorporated a compulsory short-answer section which spans the entire course. The next section required a student to answer a compulsory "problem" followed by a choice of problem-type questions. The idea behind such a format was to encourage coverage of the entire course (if only at a surface level) and to lay stress on certain basic skills. A similar lay-out exists at Intermediate Certificate level except the first section uses a multi-choice format. Although the latter was regarded as an experiment, one can only infer, in the absence of any amendment, that this procedure has proved to be satisfactory.
These changes were accompanied by a gradual trend to disenchanted on the side of teachers. There were many complaints from teachers surrounding the introduction of the 1973 changes in the Intermediate course. As noted above, they had little effect as their comments and views were not yet coordinated. However this trend altered when the amended Leaving Certificate course was drawn up for introduction in 1976. Mathematics teachers in the IMTA engaged in a more vocal dialogue and their submissions had a sizeable impact on the final syllabus adopted [40].

Gradually, as teachers and pupils became more experienced with the new courses, an unfavourable attitude emerged towards the new pure mathematical approach to secondary school mathematics. There were increasing doubts as to the ability of the axiomatic approach in helping pupils understand and appreciate key concepts and fundamental structures. Evidence of a survey carried out by the IMTA in 1973 (n = 96) concluded that [41] : (p.22)

(a) 70% of mathematics teachers surveyed considered that post-primary students would benefit from a choice of syllabi
(b) 80% considered that present syllabi in mathematics are not suitable for all students
(c) 82% thought that a significant number of students would opt for a more practical alternative syllabus.

The author from his own teaching experience would concur with this data. In particular, much of the abstract mathematics succeeds in preventing weaker students at Leaving Certificate level from acquiring a sense of achievement. Despite such criticism, the Leaving Certificate course still persists to the present day. The recent major changes in Intermediate Certificate mathematics (see Section 2.3.9) have been the result of the continuing debate on the value of the modern approach for secondary school mathematics - a continuation of the disenchanted of the 1970’s. A further examination of the effectiveness of the reform measures of the 1960’s reveals additional deficiencies.
2.3.6 Assessing the effectiveness of the 1960 reform measures

The efforts of the Department of Education, universities and the IMTA in organizing the initial in-service training courses are commendable. Furthermore, the introduction in 1965 of a mathematics syllabus committee did give mathematics teachers a degree of involvement in syllabus design which had previously been the sole prerogative of the Department of Education. These all constitute positive gains during a period of great transition in Irish education. Notwithstanding these benefits, the introduction of the new courses was accompanied by a number of serious deficiencies, many of which persist to the present day.

The in-service training which took place did not for example, emphasize adequately the philosophy behind the new courses. A lack of common purpose of what the new courses were intended to achieve did not enhance the effectiveness of mathematics teaching. The emphasis at the in-service courses was on content as opposed to methodological approaches to teaching the new courses. The courses given tended to be of a didactic nature. Feedback from mathematics teachers which would have contributed much was absent for the most part [37]. This is not to say that teachers who understood the philosophical reasons for the new courses would not have passed on valuable insights to their pupils. Furthermore, the changes introduced in 1973 and 1976 to the Intermediate and Leaving Certificate level mathematics courses were not followed by in-service training which had been a feature of the early years. This is lamentable as one of the lessons of curriculum development which emerged in the 1970's was the need to provide teachers with continuous "after-care".

If the in-service training of mathematics teachers was deficient, matters were not much healthier in the domain of pre-service training. Many graduates who taught the secondary mathematics programmes did so without having an understanding of some topics. For example, courses on transformation
geometry were rare, the reason being that university courses in Ireland have remained more "traditional" compared to those at post-primary level. No doubt such graduates experienced a sense of insecurity in their teaching. Such intrapersonal difficulties do not contribute to effective mathematics teaching. Not only did the initial training of mathematics teachers fail to address a number of topics but there was also a shortage of suitably qualified mathematics teachers to teach the new courses. Much mathematics teaching was done by science and commerce graduates or indeed by teachers with no particular qualification in mathematics at all [35]. This represented an unsatisfactory position and together with the nature of the in-service training courses constituted barriers in the path of successful innovation. In retrospect, it is difficult to see how the Department of Education expected to implement what was essentially a reformed pedagogy in secondary mathematics without appropriate and sustained efforts to improve both the pre- and post-service training of the mathematics teachers who were expected to achieve the desired outcomes.

Neither were the changes supplemented by the publication of texts for mathematics teachers and pupils, specifically designed for the new mathematics courses. Some contained errors which reflected a lack of technical knowledge. In general, their pre-occupation with abstractions did little to interest or motivate weaker pupils whose needs were not considered. Although the Department did produce notes on the new courses explaining content sections, guidance for teachers on pedagogical methods was absent. Apart from text-books, mathematics teachers in general had no additional teaching aids. The bulk of the reform measures were originally intended for the more able students [36]. Little consideration was given to the needs of different groups of students. The adoption of an axiomatic approach suited the more capable student. There was a lack of attention to applications to everyday life; instead the emphasis on associative and commutative rules in an artificial fashion succeeded only in alienating the less able pupil from their own life experiences. Furthermore, the immersion in technical
jargon and symbolism at too great a pace aggravated the plight of weaker pupils. Frustration and confusion among this group of students was inevitable. Competency in traditional computational skills including arithmetic, ability to approximate and estimate and skill in manipulative algebra suffered from neglect as teachers strove to introduce the many new modern topics [38], [42].

The new courses were introduced in the absence of a clear defensible set of aims and objectives. Moreover, the courses were implemented on a national scale without any properly controlled pilot studies or without any attempt to identify the students who were expected to benefit. Local difficulties were not taken into account in the drawing up of the mathematics courses. Collectively these represented serious and unnecessary handicaps and militated against the successful implementation of the proposed changes. Admittedly, at the time the reform measures were introduced, neither curriculum development nor educational management principles were fashionable concepts. Nevertheless, the management of the introduction of the reform measures was characterized by many shortcomings.

Significantly, there existed no appraisal or evaluative procedure to monitor both the intended and unintended effects of the new innovation. Such an appraisal mechanism would have served to identify the defects and deficiencies described above at a much earlier stage. This information could then have been utilized in the implementation of ameliorative strategies. However, the new mathematics innovation was essentially imposed from the "top-down" and swept along by powerful social forces which were in fashion at the time. It appeared as if mathematics teachers and pupils were taking part in one large reform measure without any conscious attempt to reflect on the consequences of the outcomes.

In conclusion, it is hardly surprising that the attempts to reform the mathematics courses did not meet with total success. With all the benefits of hindsight, their introduction was badly managed, failing to take cognizance of
the need for adequate attention to philosophical and pedagogical matters and without due consideration to the pupil clientele. Furthermore, the picture conjured up of the professional position of the mathematics teacher in the introduction of the new courses is a fatalistic one. Continuous in-service training for mathematics teachers did not take place. These deficiencies, together with the regrettable absence of an appraisal mechanism to monitor the effects of the new courses did not provide a recipe for genuine and sustaining success.

2.3.7 Syllabus developments in the 1970's

Changes in the syllabi and examination format introduced in 1973 and 1976 for the Intermediate and Leaving Certificate courses respectively have already been noted. The disillusion and criticisms which followed these changes in due course have also been described. The debate on the value of the modern approach to secondary school mathematics continued throughout the decade. Despite the paucity of developments, these changes were accompanied for the first time by the specification of objectives for the Intermediate and Leaving Certificate examinations.

The set of objectives for the Intermediate course was published by the Department of Education following the introduction of the new courses in 1973. These new objectives stipulated that a student should [43] : (p.40)

(1) acquire skill in computing with understanding, accuracy and efficiency
(11) acquire an understanding of mathematical facts and concepts
(111) understand the logical structure of mathematics and the nature of a proof
(1V) use mathematical concepts and processes to discover generalizations and applications
(V) associate mathematics with applications from everyday life
(V1) discover attitudes that lead to application, confidence, initiative and independence
(V11) develop study habits, reading skill and vocabulary essential for independent progress in mathematics.
As a guide to help teachers achieve objectives, it was recommended that the teaching should be resourceful, inventive and creative and should examine the student’s environment for the experiences, examples and analogies required to permit the formation, enrichment and refinement of the fundamental concepts [43]. This innovation represents a considerable improvement on the glib statement which was offered by the Department of Education in 1956 in response to a questionnaire by the International Bureau of Education, Geneva [44]:

The aims of mathematics teaching are not formally set down on any official instruction, for the reason that it would be extremely difficult to specify them. It is generally understood however that the practical aims are the cultivation of greater reasoning power and of greater accuracy in thought and expression, and that the cultural aim is the rounding off of the pupils’ general education as that education is described in the "Rules and Programme for Secondary Schools".

If the specification of objectives for the Intermediate Certificate course was perceived as an innovation, then sadly, it was not supplemented by the provision of adequate resources in the form of specifically designed texts or teaching aids. This constituted a breach of proper procedure in genuine curriculum development. There is no evidence to suggest that mathematics teachers met in small groups to discuss the implications of the new objectives. Without feedback, weaknesses were not articulated or acknowledged on a national basis. Improvements in mathematics teaching could scarcely be expected to occur with such a haphazard curriculum planning approach.

In line with the trend already established, the Department of Education specified objectives for the amended Leaving Certificate course introduced in 1976. The claim was advanced that an attempt was being made "to combine in one unified
structure topics which are traditional with those which are modern and relevant" [43]. Some of the objectives are listed below [43] : (pp. 206 - 207)

* to develop conceptual and meaningful mathematics together with efficient computational skills
* to emphasize key concepts and fundamental structures
* to show mathematics both as an abstract, autonomous body of knowledge as well as a useful, operational tool
* 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.

An analysis of these objectives is not pursued except to say that as in the case of the Intermediate Certificate objectives, they were not accompanied by extra resources, teaching aids or textbooks. Mathematics teachers were not provided with opportunities to either appreciate or help develop strategies to achieve these objectives by way of in-service education.

If the specification of objectives received attention, considerable dissatisfaction had also been expressed with the examination system in general. In 1974, the Final Report of the Committee on the Form and Function of the Intermediate Certificate Examination (ICE Report) was published [45]. The report suggested (p.V) that the Intermediate Certificate examination served no useful purpose. The Committee proposed a system of school-based assessment monitored by a central body which would take responsibility for all aspects of curriculum assessment, helping teachers to clarify educational objectives, providing external tests and opportunities for school-based assessments. However, the recommendations made in the report were not implemented and the Intermediate Certificate examination remained. The Madaus and MacNamara report [46] on the Leaving Certificate was critical of the reliability and validity of the examination at this level. The study found that the examination at both Pass and Honours level might well be little more than largely a
measure of memorized knowledge [46].

Apart from the changes introduced into the secondary mathematics courses in 1973 and 1976, there was a distinct lack of centrally planned change from the Department of Education. Nevertheless, curriculum development was growing more familiar in Ireland and the notion that teachers have a role to play in course design and examinations was becoming more acceptable. A Curriculum Development Unit in Trinity College was set up in 1972 and a Curriculum Development Centre was established in County Clare to promote curriculum work. The founding of the Irish Association for Curriculum Development at this time is further indication of the growing interest in this area. Indeed the IMTA in 1973, after considering the unsuitability of the mathematics courses for the majority of pupils, began to formulate less abstract courses for the weaker pupils [41]. A trend of teacher involvement can thus be identified, even if the large majority of mathematics teachers were not involved. A number of initiatives in the 1970's lends support to the idea that mathematics teachers were becoming more closely involved in curriculum development work. These experiences are elucidated in the next section.

2.3.8 New experiences in mathematical curriculum development projects

1 The I.M.U. Project

IMU stands for individualiserad matatik-undervisning, which means individualized mathematical instruction and represented

3. The author is grateful to Mr. P. Crowley, a psychologist with the Department of Education in Cork (who was involved in the project) for lending the author a rare copy of the IMU evaluation report.
an independent learning system to teach mathematics to junior cycle second level pupils. It was developed in Sweden in the 1960's with the aim of permitting pupils to proceed at their own pace and at appropriate level of difficulty, while remaining in a mixed-ability group. Essentially, the system involved pupils working individually on a series of booklets which contained all the necessary instruction, exercises and tests. These were available at a number of levels of difficulty. The teacher administered the system and was available for small group tuition or individual consultation. Through the auspices of CERI/OECD, the system was introduced on an experimental basis to a total of twenty-one Irish schools in the period September 1970 to June 1972 to teach junior cycle mathematics. The IMU materials were also used in Norway, England and Wales [47].

Two Inspectors from the Department of Education travelled to Sweden in 1969 and recommended that the IMU system be adapted on a trial basis in Ireland. In Ireland, as well as in Britain, the primary reason for experimenting with IMU was the interest in devising means of dealing with mixed-ability classes [47]. Comprehensive and community schools were beginning to make an appearance in Ireland at this time and it was felt that classroom techniques which may have enjoyed some success with streamed classes had more dismal prospects with mixed-ability groups. The involvement of the Department of Education was part of a larger feasibility study by the Centre for Educational Research and Innovation (CERI) of the international transfer of learning systems.

The evaluation report was of an eclectic nature and its illuminative style concerned itself primarily with description and interpretation [47]. In the process, it has provided valuable insights into the operation of an innovation in the Irish post-primary context. Various styles of operation of the system in classrooms were observed, demonstrating that the mathematics teacher had a significant role to play, even with an independent learning system. However, in the second year, teachers were more inclined to control pupil progress than had been the case in first year and to reduce the time spent
working with individuals. A majority of teachers felt that IMU facilitated good pupil-teacher relationships and general satisfaction was expressed with IMU materials. The methodology of IMU was found to be at variance with the traditional approach to mathematics teaching which existed at the time. The IMU approach was of a spiral or cyclical nature while the tradition in Ireland at the time was to develop a smaller number of topics fully in the early stages - more of a vertical approach. The report (p.28) suggested that this difference in approach deflected teachers' attention somewhat from more important features of the system and caused some practical difficulties for them [47].

The IMU system was competing with the constraining influence of the examination system in the sense that IMU was not part of the public examinations. The importance of examinations for teachers was verified in a later study by Raven who found that Irish secondary teachers are to a rather alarming degree examination orientated [48]. There is no doubt, therefore, that the prevailing examination and teaching approaches militated against the successful implementation of IMU. The mathematics teachers involved did recommend that the system could benefit from the inclusion of more items and concrete material to stimulate creativity and problem-solving. It was also felt that expertly guided group discussion and co-operative projects could greatly facilitate the integration and consolidation of mathematical knowledge. With regard to pupil attitudes, it was found that IMU pupils were more favourably disposed to mathematics than their control group counterparts although the level of enthusiasm dropped in the second year of the project. The main reason postulated for this decline was difficulties with the normal second year mathematics syllabus, resulting from the discrepancy between the mathematical content of IMU and the usual first year course [47]. The fact that the IMU system was novel and different may account for the initial enthusiasm rather than the actual innovation per se. Innovation was new to the Irish education system at this time and hence the difficulty of distinguishing between responses to the actual innovation and the actual process as encountered.
Retrospectively, the IMU system must be seen in the context of innovations being totally new to Irish mathematics teachers. Indeed Crooks et al [49] has noted (p.32) that in many respects, IMU was the precursor of much curriculum development work in Ireland. However, the impact of the innovation was restricted by the minimal training received by mathematics teachers in the use of the system and in fact they had no experience of a predominantly material based approach. A further restriction was the influence of the prevailing approach to teaching and examining which stood in contrast to the principles inherent in the IMU approach. These contextual constraints prevented IMU from functioning effectively. Moreover, the illuminative report identified a number of complex process variables which give some indication of both the difficulty and complexity of implementing and sustaining innovation in Irish post-primary schools. The institutional climate of the school for example, was found to have been of major influence in the sense that pupils belonging to a regimental/formal school setting took to IMU much more rapidly and enthusiastically. The report instances an occasion where one IMU mathematics teacher complained that the French teacher had taken over usage of the tape-recorder (which had been supplied specially for IMU use) and that the IMU tapes had been erased [47]. Although these may appear trivial, such insights shed light on how school ethos and colleagues exert a constraint on teacher performance. It is only in recent years that the complexity of school process factors has been acknowledged as important. The IMU project has contributed to improving this understanding of within-school life vis-a-vis innovatory projects by elucidating some of the complex contextual processes which abound. In so doing, it has also manifested the difficulty of distinguishing between responses to a system of education which was alien to innovation.

IMU was a case in point. Sadly, the project came and went without contributing to the initiation of work which would have capitalized on the experience gained. Mathematics teachers were provided with opportunities to adopt a new role and methodology but the memories of such an experience were
soon to fade.

II The Public Examinations Evaluation Project (PEEP)

The Public Examinations Evaluation Project (PEEP) was the name given to the research unit by the Committee on the Form and Function of the Intermediate Certificate Examination (ICE Committee). The project began in 1973 before the ICE report was completed and the unit continued in a full-time capacity until 1977 and after that in a part-time capacity until 1980. The project issued four reports which were published by the School of Education, Trinity College, Dublin.

The ICE Committee asked the project to concern itself with [50]: (p.1)

- the devising of examinations which will demand high level skills than are at present exercised in the Intermediate Certificate examination
- the possibilities of large scale use of objective rather than essay-type examinations, and their advantages in reliability and speed of scoring
- the involvement of teachers and school authorities in the assessment of their own pupils
- in collaboration with the syllabus committee, working toward the further training of teachers in the devising of their own examinations, so that the expertise of the project team would be spread through the post-primary system.

Mathematics and History at Intermediate Certificate level were the two subjects chosen for development. As the unit was not sufficiently large to embark on the simultaneous development of mathematics and history, mathematics did not receive the same treatment as history. As a result of initial in-service training programmes, mathematics teachers developed experimental forms of assessment to test the validity of the theory of multiple-objective assessment for the examining of fifteen year old pupils.

In 1975, three objective tests were set. Two were set for the Pass and one for the Honours level Intermediate Certificate mathematics. The objectives tested knowledge, comprehension, application, analysis, manipulative skills and synthesis.
Although the deliberate attempt to test for specific objectives contrasts with Department of Education procedures, the project team demanded no specific teaching for these objectives. However, the working party after a number of week-end workshops arrived at the following aims for mathematics teaching [50] : (p.19)

(1) practical application with relation to everyday life
(II) relationship with other subjects
(III) preparation for further study
(IV) intellectual value
(V) aesthetic value.

A specific but limited mathematics project was then established to evaluate the relationship between levels of achievement and understanding as defined by behavioural objectives in relation to teaching strategies on the one hand and factors such as general intelligence, personality and interests on the other hand. To achieve this end, a short multiple aptitude test and personal inventory were among the criterion measures which were chosen. A novel feature of the study was the inclusion of a pupil-rating scale where pupils were asked to rate on one four point and five three point scales their attitudes.

The main limitation of the work of PEEP lay in the reality that it had no authority to offer alternative syllabi for mathematics teachers to compare with the existing state examination. As one report of PEEP puts it [50] : (p.17)

The present syllabus dictated events and no attempt was made to introduce some form of coursework, or design examinations along the lines suggested in Report No. 2 (p.53).

It was suggested that in future, experiments of this kind should be related to the award of a separate but equally valuable certificate. Furthermore, the mathematics teachers involved in the project were a specially selected group. Although the period for the development of the mathematics examination was too short, the project is evidence of teacher ability and enthusiasm in the design of objective items and in
the actual assessment of students. In addition, it is fair to say that the terms of reference of the project as outlined earlier were in conflict with those of the syllabus committee which determined state syllabi. Thus, the public examination system had an overriding influence on the effective dissemination and uptake of the insights and understandings gained from PEEP. Many teachers are not willing to administer experimental examinations unless there is a "pay-off" such as preparation for the Intermediate Certificate examination. This was not the case with PEEP.

The final report of the project, published in 1980, suggests the need for three levels of examination at Intermediate Certificate level [51]. Level 1 would equate with the present Honours course and level 2 to the present Pass course. The third level would meet the needs of weaker pupils and would derive from a substantially different programme designed to help such pupils achieve mastery in basic skills for which a certificate of competency would be awarded. Finally, the report suggested the introduction of a system of examination and moderation in which the teachers working in consortia would be the first markers of their pupils' scripts. The concept of a three-tier system of assessment for the Intermediate Certificate examination and the greater emphasis on a public examination component of assessment indicates that a more flexible approach to public examinations was being advocated. These issues and suggestions were to reappear and emerge as significant in the mathematics debate in the mid 1980's concerning the appropriateness of curricula and related assessment procedures to the world outside the school.

III Pre-Employment Courses and the European Community Influence

Throughout the 1970's there was increasing criticism of the education system and the manner in which post-primary schools prepared pupils for working and adult life [14], [52].
Soon after joining the European Economic Community in 1973, Ireland became involved with other member states in devising new approaches to improve the preparation of pupils for working life and to facilitate the transition from school to work. As a result, two initiatives were introduced. Firstly, in 1977, the Department of Education invited post-primary schools (except private secondary) to introduce pre-employment courses to ensure a smooth transition from school to adult life for these pupils who would ordinarily leave school on attaining school-leaving age. The course consisted of three broad areas:

1. technical modules
2. general studies which included personal and social development
3. work experience.

The general studies course involved courses on communications, social mathematics and industrial/social studies. The goal was to develop pupils’ standards of communication and mathematics to the level required in work and in everyday life. After one year, some one hundred and twenty schools had taken on the course [49]. Later, in 1984, the pre-employment course was subsumed in a new innovation entitled the Vocational Preparation and Training Programme. All second level schools were allowed to participate in the latter programme. Indeed the Department of Education is to be applauded at the manner in which it has allowed teachers reasonable discretion in designing and implementing these courses together with its increased efforts to provide course guidelines and in-service training. Williams et al [53], in an appraisal and practical guide designed to assist schools undertaking the programme comments positively on the implications and benefits which can accrue from teacher involvement in curricular initiatives: (p.6)

From the point of view of teachers' professionalism, experience working on this and similar programmes had confirmed our conviction. that, given freedom, finance and planning time, teachers themselves can devise curricula of genuine interest to and value for their students.
The second initiative emanated directly from an agreement by EEC member states to establish a network of twenty-nine projects throughout the European Communities; three of these were located in Ireland with Department of Education approval. One of these projects was called Education for Development and was located in North Mayo. The project began in 1978 and its primary input came from the work of the Galway/Mayo Regional Development Organization and the Irish Foundation for Human Development. The project was concerned with the nature of the learning experience at second level and its primary aim was to help develop students' ability to learn. To help achieve this aim, three types of intervention were used. One of these was called "imagining" and it was asserted that imagining is a significant factor in developing intuitive thinking abilities and stimulating creative action [49]. Lessons incorporating this process were devised and introduced into mathematics. Ten schools were involved in the project.

The North Mayo initiative was not concerned with the formulation and development of a special programme aimed at a specific subgroup. However, attention is now turned to a mathematics project which did attempt to meet the needs of Leaving Certificate pupils for whom the Pass mathematics course was unsuitable.

IV An Alternative Mathematics Project for Leaving Certificate pupils

In 1979, the Vocational Education Committee (VEC) of County Tipperary (North Riding) initiated a review of the relevance of its educational provision at post-primary level vis-a-vis the needs of the economy. Recommendations for future policy in the administrative district were included in a report entitled: Post-Primary Education 1985-2000 and its relevance to the Economy: A Policy Document [54]. One recommendation called for the establishment of an alternative course in
mathematics at senior cycle. A number of factors have been identified as being influential in this area of concern [55]: (p.42)

(I) failure rates in state examinations
(II) pupils' frustrations and lack of success with conventional mathematical syllabi
(III) parents expressed concern for their children's future employability
(IV) employer dissatisfaction with the preparation of school leavers for work
(V) an awareness of the international debate on the value of the new modern approach to mathematics
(VI) an awareness that educational goals and the needs of the economy were not necessarily incompatible aims.

O'Donoghue et al (p.42) articulate the prevailing climate at the time [55]:

There was widespread concern among pupils, parents, teachers and employers that existing arrangements were neither adequate nor appropriate for the mathematical needs of all children especially those (the majority) seeking to go directly from school to employment.

A working party was subsequently set up to devise the new alternative mathematics programme. The aim of the programme was to attempt to meet the needs of senior cycle pupils who chose to go directly from school to employment by providing a sound mathematical programme designed to help them make a living in a modern technological society [55]. The aims were accompanied by specific objectives couched in behavioural terms. The launching of the project involved impressive dialogue and cooperation between the VEC, mathematics teachers, a local third level lecturer in mathematical education together with the involvement of employers and industrialists.

It is possible to identify a core of essential mathematical skills in the programme. Pupil motivation is enhanced by the applications orientated approach of the course. The self-paced feature helps to promote pupil confidence. A concept of mastery learning is employed in the teaching of the programme. Computer studies is included as a component of the syllabus.
Certificates are awarded to successful pupils by the VEC. The credibility of the project received a boost when AnCo (the National Training Authority) recognized the certificate for the purposes of apprenticeship and for clerical appointments. However, the Department of Education refused to recognize the course as a full alternative to the Leaving Certificate Pass mathematics programme. Although a number of secondary schools outside the North Riding Tipperary VEC district did adopt the new course, dissemination on a national scale has not occurred.

In an external evaluation of the project Bajpai [56] (p.15) noted the tremendous enthusiasm and commitment of students who pursue the course and the teachers who teach it. Pupils were particularly appreciative of the self-paced learning component and the applications oriented bias inherent in the programme [56]. The report suggests (p.17) that a primary reason for the small uptake of the project in schools is due to the non-recognition of the programme by the Department of Education in terms of equivalence to the Leaving Certificate Pass level examination [56].

On reflection, the project constitutes an interesting innovatory exercise in local school/scheme-based curriculum development in the Irish post-primary context. The rationale, specification of aims and objectives, the willingness of mathematics teachers to take up the challenge and adopt new teaching styles and the emphasis towards application and relationships to "real-life" situations are all commendable features which deserved wider support. The realization of the project was the culmination of impressive collaboration and dialogue between educationalists and industrialists. This concept of partnership has potential implications on a national scale. The failure of the project to become implemented on a widespread basis is a sharp reminder of the formidable difficulties of achieving curriculum change while operating on the periphery of a centralized examination dominated system. The PEEP project described earlier also identified the existing syllabi as a severe limitation.
Nevertheless, the concept of partnership encapsulated in the project is a dynamic and fruitful one, one which has relevance for mathematical education in the present day context.

In general, the experience of these curriculum development projects indicate a new level of teacher involvement whether the initiative came from the Department of Education or local level. A new interest in curriculum development was aroused. In attempting to meet the challenge of change and criticism, problems of pedagogies and curriculum design were encountered. However, the formidable difficulty of achieving curricular change, while operating on the fringes of a centralized system of education with centrally prescribed mathematical syllabi, can be identified as the primary reason for the failure of these projects to gain acceptance at national level. In effect, this ensured that the isolated post-primary mathematics teacher, hamstrung by a restrictive curriculum remained the norm. Notwithstanding this, the experience and insights gained from all these initiatives highlight the possibilities and the problems that are inherent in achieving worthwhile change. This is particularly true of issues such as school-based assessment, local/school certification and the generalization of outcomes from pilot projects. They remain as case studies which can be utilized as a source of material in future attempts to resolve fundamental issues.

The dissatisfaction with the mathematics courses, especially their unsuitability for weaker pupils, continued into the 1980's. New educational initiatives were to emerge from central government, which held out hope for those concerned with the shortcomings of the present system. New changes in mathematical syllabi were introduced, but as the next section indicates, the role of the Department of Education remained as preponderant as in previous decades, with little attention being given to the teacher-pupil domain.
2.3.9 Recent developments in secondary school mathematics

Revised syllabi at Intermediate Certificate level

The establishment of the interim Curriculum and Examinations Board in 1984 was the government's response to the widely held view that major changes were needed in curricular and assessment procedures. In 1985, the Minister of Education decided to transfer the functions of syllabus committees (which had been in existence since 1965) to the new Board [57]. However, the existing committees were allowed to complete work which was at an advanced stage. This included the mathematics syllabus committee which had been engaged in comprehensive syllabus renewal since the early 1980's in their attempt to construct new syllabi at three levels - syllabus A for the more able pupils, syllabus B for those pupils of average ability and syllabus C for low achievers. The last revision of the Intermediate Certificate mathematics programme was in 1973 and that of the Leaving Certificate programme in 1976. Thus, the process of appraisal and review was long overdue.

From the outset, the determination to construct syllabi at three levels represented a significant change in syllabus and examination reform. The major consideration had been the continuing dissatisfaction expressed at the ability of the current syllabi to meet the needs of all pupils especially the less able pupils. The high failure rate (approximately twenty per cent) on the Pass Intermediate Certificate mathematics examination provided ample evidence of the unsuitability of the syllabus for these weaker pupils. This had been a recurring theme of the mathematics debate during the 1970's.

A closer look at the work of the syllabus committee during this period of programme renewal generates insights into a number of considerations which helped to shape the outcomes which emerged. Firstly, the mathematics teachers who actually sat on the syllabus committee contributed significantly to the
debate [12]. Throughout the period of consultation and discussion, draft syllabi were produced and all mathematics teachers were strenuously encouraged to comment on the proposed changes [58]. However, in general, the response from practising mathematics teachers was poor and it was the mathematics syllabus committee, working earnestly and hard, who eventually determined the nature of the syllabi for national implementation [12].

In general, matters of content occupied the centre of the debate. Geometry proved to be the most contentious topic both for syllabi A and B. In relation to syllabus B, the committee was virtually unanimous in urging a departure from the prevailing approach. An approach based on congruence was suggested due to the power and simplicity of the concept and the early drafts of syllabus B included theorems to be proved in this fashion. Later, the question of whether the formal learning of geometrical proofs should be required of pupils at all was debated. The view was expressed that the recalling of formal theorem proofs for examination purposes was of little value. It was time-consuming for teachers, frustrating and largely meaningless for the majority of pupils and its contribution to their mathematical education questionable. As an alternative, an intuitive approach based on measurement and distance was proposed as being more related to experience in reality. In this manner, it was claimed that all the geometrical facts, at present learnt as formal proofs, could be acquired by pupils without the accompanying drudgery and frustration [58]. When the final syllabi were sent to post-primary schools in September 1986 (a year in advance of their introduction), it was indicated that the formal proofs of theorems would not be expected of students taking syllabus B (see Appendix A).

When syllabus A came up for discussion and debate, no great problems arose with the content of the algebra and arithmetic sections but there was serious disagreement over the method of proof to be used in geometry. In general, teacher representatives wished to see the concept of equipollence removed from the syllabus on the grounds that it was too
abstract and that to ignore length and to postpone mention of
distance for as long as possible was unreal and contrary to
experience. It was argued that the transformations of the
plane were taught in metric terms and should, therefore, be
defined in metric terms. This proposition was debated over
three meetings and the outcome resulted in the formulation of
an agreed set of axioms and proofs of theorems by congruence
arguments. The inspectorate of the Department of Education
insisted on the retention of the concept of equipollence to be
used to prove the axioms on which the congruence proofs were
based and as an alternative basis for the proofs of the
theorems. They also continued to insist on defining the
transformation of the plane in terms of equipollence rather
than in metric terms [59]. Shortly before syllabus A was due
to be published, the syllabus committee received a letter from
three Irish Professors of Mathematics expressing their
dissatisfaction with the geometry content in syllabus A [60].

They advocated that some proper full course on geometry should
be included, for example, one of those due to Euclid-Hilbert,
Birkhoff, Choquet or Papy in the sense that the terms
employed, the sequence of theorems and the type of proof used
ought to be compatible with such a full course. In
recommending a re-draft of the geometry section, they
suggested the suitability of the Euclid-Hilbert context and
emphasized the need for the inclusion of Pythagoras' theorem
and ratio theorems for triangles as a basis with which to
start trigonometry and co-ordinate geometry. The implications
of this approach meant the dropping of the concept of
equipollence and terminology involving couples from the
graphy section of the course. After a full discussion, the
syllabus committee decided to adopt the position taken by the
Professors and the geometry content of the syllabus was
amended accordingly. Thus, when syllabus A was eventually
published in 1986 (see Appendix A), it contained no list of
axioms and the transformations of the plane were defined in
metric terms and not in terms of equipollence. Such
amendments indicate the high esteem which Professors of
Mathematics enjoy in the Irish context and the influence which
they can exert on the teaching of secondary school mathematics.
The revised syllabi for junior cycle mathematics took effect from the beginning of the 1987-88 school year for examination in 1990. They were accompanied by sample papers but specific texts were not published by the Department of Education. Instead, it was left to private enterprise to take up the initiative and the response was both enthusiastic and competitive with some texts catering specifically for syllabus C. The lack of adequate in-service training for mathematics teachers taking on the new courses has been disheartening. Those courses which were made available demanded teachers giving up holiday time and minimal expenses constituted a further disincentive. Once more, little or no attention was focused on the reality of the teacher-pupil classroom situation. The task of the mathematics teacher was simply to implement a central directive in the best possible fashion in the absence of in-service training, resource aids, discussion and research. Altogether, the picture conjured up is of the secondary mathematics teacher who is not in control of the destiny of his mathematics teaching. While mathematics teachers must take some blame for not contributing submissions in large numbers during the debate of the revised syllabi, they have been positively handicapped by the failure of school principals to provide a context for dialogue and debate.

In common with the reform measures of the 1960’s, the new innovation was introduced in the absence of any comprehensive testing of the new syllabi by way of pilot studies. Moreover, the objectives of the new syllabi correspond exactly to those introduced for the first time in 1973. The failure to reappraise the appropriateness of these aims after thirteen years at a time of rapid societal and technological change is particularly worrying and disappointing. Furthermore, the same statement of objectives has been offered as suitable for all three syllabi when clearly the needs of pupils at each level do not coincide. Neither has there been any attempt to show how these objectives relate to the Leaving Certificate mathematics course. In 1982, the Report of the Pupil Transfer Committee [61] indicated that the mathematics programmes for primary and post-primary schools were out of alignment with
each other as the two programmes were drawn up quite independently of each other. One of the aims of the primary school programme in mathematics is "to lay a foundation for further work at post-primary level" [62]. The secondary school mathematics programme ought to take cognizance of this aim to help reduce transition problems. Regrettably, neither this suggestion nor those in the aforementioned report were considered in the construction of the revised Intermediate mathematics syllabi and the unsatisfactory position of little or no liaison between primary and post-primary mathematics teachers remains.

Again, in common with the reform measures of the 1960's, content had too privileged a place in recent developments. The preamble to the revised mathematics syllabi at Intermediate level contains no statement on teaching methods. Some of the summer in-service education courses did look at strategies and textual material. One such in-service course was Mathematics and the Underachievers, organised by the Department of Education in August 1988. It concentrated on syllabus C but, in general, the matter has not been pursued with the same urgency as changes in content received. There is, perhaps, a basic assumption that teachers are competent to work out appropriate methods for themselves. The new syllabi contain notes on the various sections of the course. These are aimed at definition and explanations of the content rather than pedagogical guidance. No mention is made for example of how the advent of the microcomputer could enhance the understanding and learning of mathematical topics. Materials other than textbooks are not very prominent. Altogether, matters of pedagogy have received insufficient attention. No forum existed for discussion of the specifically teacher-pupil classroom situation, as it is, and as it may be, when the reforms are implemented. This is disturbing at a time when secondary mathematics teachers are already faced with complex demands by the onslaught of societal and technological change. Research is needed to investigate if mathematics teachers themselves are aware of the cumulative effects of these demands and whether their professional standing gives them a solid basis for absorbing and coping with the increasing burden.
No formal largescale evaluation project was established to judge the effects of the reform measures of the 1960's. There is no reason to believe that this trend will be reversed in the case of the most recent innovation. This is a breach of proper procedure in innovative curriculum development. How can educational progress occur, if, in the absence of acceptable appraisal procedures, mistakes remain unremedied?

Finally, a characteristic of the most recent innovation is that the revised syllabi are being used as a foundation to develop Leaving Certificate mathematics courses. This follows the trend of changes introduced in 1966, 1969, 1973 and 1976. It is hoped that pupils introduced to the revised mathematics syllabi at Intermediate level will proceed to amended syllabi at Leaving Certificate level in 1990. Indeed, the process of revision for the Leaving Certificate mathematics courses had begun in 1985 [25], even before the revised syllabi for the Intermediate course had been published. Draft syllabi have been constructed for the new Leaving Certificate courses for syllabi A and B [25], [60]. A noteworthy feature of these draft syllabi is the option to attempt a question on computer applications, although many of the topics contained in the proposed computer option for syllabus B appear to be beyond the ability of the pupils for which it is intended. The list includes [25]:

(I) computer logic/Boolean algebra
(II) random numbers (Monte Carlo methods)
(III) iteration
(IV) area: triangle formula
    trapezoidal rule
    Simpson’s rule
(V) programming exercises related to content.

It is not surprising that the debate to date for revised syllabi at Leaving Certificate level has focused on content issues especially geometry, trigonometry and vectors. The process of revision for the Leaving Certificate mathematics syllabi is continuing at present.

A separate development in 1985 resulted in pupils being allowed to use electronic calculators at the Leaving
Certificate mathematics examination. Consequently, questions involving the use of logarithmic tables were no longer set. The latter type questions were also omitted from the Intermediate Certificate examination although calculators were not permitted.

These developments in mathematics were taking place at a time of great flux in Irish education. Curriculum reform, syllabus renewal, alternative courses and modes of assessment were very much live issues in the mid 1980's. The setting up of the interim Curriculum and Examinations Board (CEB) in 1984 was perceived by many as heralding a new era in curriculum and examinations reform. Its many "consultative" documents were launched amid much excitement and an air of optimism and expectation prevailed. The influence of the CEB on post-primary school mathematics is considered in the next section.

II The influence of the Curriculum and Examinations Board

An early decision of the CEB was to set up Boards of Studies for various curriculum subject areas. The primary function of these Boards of Studies was to devise the general curriculum and assessment principles necessary for the development of syllabi and courses in the various subjects. They were also asked to co-ordinate the work of the various course committees which were being established to replace the existing syllabus committees. It was hoped that these new course committees would have both a curriculum and an assessment function to ensure closer alignment between what was taught and how it was to be assessed [57]. The course committee for mathematics was established in 1986 after the existing syllabus committee had completed its revision of the Intermediate Certificate mathematics programme. The course committee for mathematics proceeded in its task to smooth the transition for the introduction of the revised syllabi.

During the early meetings of the mathematics course committee,
a number of issues arose. Firstly, the role of the calculator in the teaching of mathematics at junior cycle was considered [63]. The course committee believed that the calculator had an important function in mathematics education and that its introduction should be encouraged and facilitated at junior cycle level. It subsequently emerged that the CEB assented to the recommendations of the course committee on the use of calculators for junior cycle. Accordingly, in February 1987, it was decided to proceed with the design of sample papers for the revised syllabi at junior cycle on the assumption that the use of calculators would be permitted in the Intermediate Certificate examination in 1990 [64]. Secondly, a debate arose over the problem of aligning grades between the different levels of assessment in syllabi A, B and C for the revised syllabi at Intermediate Certificate level. Originally, syllabus C was to be examined by only one paper. The course committee decided that two papers would provide a better sampling of the course, afford candidates a better opportunity to score and facilitate comparability between syllabi C and syllabus B by making the second paper common to both. Similar arguments to ensure comparability between syllabi A and B resulted in the agreement of the following structure [64]:

<table>
<thead>
<tr>
<th>Syllabus</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Papers</td>
<td>III</td>
<td>II</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>III</td>
<td>II</td>
</tr>
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</table>

Thirdly, the merit of school-based assessment was considered. However, its introduction was not perceived as realistic as it involved implications of time, finance and industrial relations. In particular, thorough in-service training for mathematics teachers and adequate monitoring were advocated as being crucial to ensure credibility [64]. Finally, an attempt was made to specify assessment objectives for syllabi A, B and C at junior cycle [64]. However, due to an internal disagreement between the CEB (now called the National Council for Curriculum and Assessment) and the Department of Education over aspects of the sample papers for the revised syllabi at Intermediate Certificate level, no mathematics course
committee meetings have been held since May 1987. As a result, no assessment objectives or procedures are available for pedagogical guidance and the process of rolling development has ground to a halt.

One further significant initiative by the CEB deserves mention. Soon after the Board of Studies for Science, Technology and Mathematics was established in 1985, a special sub-committee was set up "to assist the Board of Studies in the formulation of general curriculum and assessment principles related to the teaching, learning and assessment of mathematics at primary and post-primary level" [65]. Representatives from teacher unions, third level and the inspectorate of the Department of Education were involved in the deliberations of the sub-committee. The report of the sub-committee formed the basis of a discussion document issued by the CEB in early 1986 entitled Mathematics Education: Primary and Junior Cycle Post-Primary [65]. This was the first time since the foundation of the State that a specific document had been published where the primary concern was "the teaching and the learning of mathematics throughout the compulsory period of schooling" [65]. Although the document moved the debate on mathematics education forward, it is more noted for its limitations than its strengths.

In the foreword to the paper, it is stated (p.5) that the central role of mathematics in the education of young people has too often been taken for granted. The reader could be excused for thinking that the value claimed for mathematics in the curriculum would be clearly stated to help justify particular aims and objectives in mathematics education. However, no justification emerges from the document for attaching great importance to the teaching and learning of mathematics. The paper purports to address crucial issues such as the need to provide a rich mathematical experience for all students, the need to foster positive attitudes towards mathematics and to foster the ability of young people to apply mathematics to real situations of their own accord [65]. It is questionable whether these represent the central issues when a number of fundamental questions were not raised. Questions
such as "why teach mathematics?", "what is the place of mathematics in a technological society?", "how does mathematics relate to general educational goals?", "what is the intellectual worth of learning mathematics?", "how is mathematics of value to the pupil?", "who will teach mathematics and how will they teach it?", or "what are the elements involved in bringing about change in mathematical education and in particular the role of the mathematics teacher?" do not receive consideration. Admittedly, the paper indicates a willingness to confront some of the problems within mathematics education but some two years later, there is no indication of an action plan to implement its recommendations.

An adequate mathematical education for a nation's children at all levels ultimately depends upon the quality of its mathematics teachers. This in turn is dependent upon the education and training of such teachers which must be adequate, appropriate and thorough. This was not the case during the reforms of the 1960's as noted earlier. It is appropriate therefore to examine the genesis and structure of the present training system for post-primary mathematics teachers.

2.3.10 The education and training of post-primary mathematics teachers

The Teachers' Registration Council, originally established in 1918, lays down requirements for secondary school teachers. With regard to teaching mathematics in post-primary schools, the only requirement is a primary degree from a recognized university and a qualification in teacher education and training. There is no requirement to have studied mathematics at university, or to have taken the subject in a degree examination. For the most part, the training of secondary school mathematics teachers is conducted within the universities which adopt the consecutive model i.e. where the professional/pedagogical element follows the undergraduate
academic course. The professional course is called the Higher Diploma in Education and is a one year post-graduate course offered by each of the five university colleges. Theoretical and methodological issues are covered and students are expected to engage in teaching practice in approved schools and under authorized supervision. Clearly, such a brief period of pedagogical training cannot be considered adequate for the very demanding profession of teaching. The requirement of no more than one hundred hours of teaching practice is evidence of the inadequacy of the Higher Diploma course and consequently, a disproportionate part of the post-primary mathematics teacher’s training has to be gained at the expense of pupils. Undoubtedly, within such a limited period of training, there can be little real opportunity for acquiring an insight into such issues as effective mathematics teaching, class discipline, use of audio-visual and other teaching aids or the merits of action-research for the improvement of classroom practice. In effect, the course in pedagogical training is much too brief for post-primary mathematics teachers to acquire a proactive and self-renewing perspective on their teaching which ought to be characteristics of the future mathematics teacher.

It is fair to say that many undergraduates of the Arts, Commerce and Science faculties, who up to then had no particular leaning towards teaching, embark upon the Higher Diploma in Education for no reason other than it is a natural progression of the academic structure to which they are accustomed and because on the successful implementation of the course, they will be qualified for entry to a profession. Thus, while the great majority of post-primary teachers are such by choice, there is within their ranks a number (including mathematics teachers) who have drifted into the profession. Indeed, in the late 1960’s, following the introduction of free education, the demand for secondary school teachers increased considerably and with it, understandably, an unsatisfactory number of “drifters”. As Doorley [66] puts it:
It was a damaging era for the quality of Irish secondary teaching. Too many of the leftovers of the university system came to feed, like parasites, on the teaching profession. Most of these walking disasters are still there, still engaging in chalk and talk.

A post-primary school mathematics inspector from the Department of Education, in a recent correspondence to the author, illuminates this issue further when he referred to the absence in general by post-primary mathematics teachers of a genuine interest in the subject and too close adherence to the text-book [67]. No doubt, some of these "drifters" turned out to be capable practitioners, but a number of them would probably have enjoyed greater success and happiness in another vocation.

Currently, recent cutbacks in education, combined with decreasing pupil enrolments, have virtually ensured that even those students who had a genuine and true vocation for teaching and who went to great expense to qualify will be prevented from following their chosen career. Clearly then, it is unworthy of the teaching profession that entry to it or exclusion from it should be of such an incidental nature. Some form of selection to include a testing of the candidate's aptitude for the profession should be introduced as a necessary ameliorative measure.

In any case, much of secondary mathematics teaching has been done by graduates of the Arts, Commerce and Science faculties. In vocational schools, teachers of metalwork and woodwork are often expected to teach Intermediate Certificate mathematics. In many other schools much instruction in mathematics is carried out by teachers with no particular qualification in mathematics. A supply of suitably qualified secondary mathematics teachers continues to remain a problem today - a problem not just confined to Ireland alone [68]. Thus, the Department of Education has not succeeded in facing up to the challenge in providing adequate pedagogical training for secondary school mathematics teachers. Earlier, it was noted that this situation constituted a barrier towards the successful implementation of the reforms in the 1960's and
1970’s. There is every reason to believe that the present revised syllabi will experience a similar fate in the absence of any firm commitment to improve the education and training of post-primary school mathematics teachers.

An opportunity was seized in Thomond College of Education in 1975 to develop a new approach to the education of secondary school mathematics teachers in Ireland. Instead of looking to the universities, it was deemed more appropriate to concentrate on what was happening in school mathematics, with specific emphasis on 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. The mathematics 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 [4]. The essential features of the mathematics programme are integrated and concurrent in the four-year programme. It is worthy to note the criteria which were used in judging the acceptability of mathematical content in the programme [4]:

* internal relevance
* applications value
* functionality.

Three courses deserve special consideration viz. Computer Studies, the Mathematics Seminar and History and Nature of Mathematics. In particular, the inclusion of Computer Studies in a programme of initial training for mathematics teachers was still novel in the Irish context. Courses are taught by a variety of methods including lecture/tutorial format, seminars, workshop sessions. Use is also made of Personalized Systems of Instruction (PSI). The impact of the programme has been impressive [4]. Students who have found employment teaching mathematics in secondary schools have received favourable comment from the inspectorate, who send reports to the college periodically as feedback. As a graduate of the Mathematics Programme, the author found the entire course
exceptionally good and well designed for its purpose. As a practising teacher of mathematics to Honours Intermediate and Pass Leaving Certificate levels, the author would add on a personal note that his programme of initial training in mathematics at Thomond College of Education has helped him greatly in becoming adaptable and flexible in a rapidly changing world, a criterion which ought to be an integral part of any teacher education programme.

An interesting additional feature of the Thomond College Mathematics Programme is its link to the Centre for Advancement of Mathematical Education in Technology (CAMET), at Loughborough University of Technology in England. CAMET was founded in 1966 by Professor Bajpai, Head of the University’s Department of Engineering Mathematics of which CAMET is a subset for administrative purposes. The centre’s single aim is to advance mathematical education. CAMET is engaged in all aspects of mathematical education including the training of mathematics teachers and has earned a high reputation internationally for the quality of its innovative work. In November 1979, CAMET (Ireland) was established at Thomond College of Education – the first regional centre affiliated to the parent organization. The centre is engaged in activities designed to advance mathematical education in Ireland including the education and training of mathematics teachers for post-primary schools, computer education/studies and the development of an alternative employment-oriented mathematics course for students in the senior-cycle of secondary schools. CAMET (Ireland) through its association with CAMET also provides opportunities for selected experienced mathematics teachers to pursue higher degrees by research. The degrees are awarded by Loughborough University of Technology.

Little mention has been made to date of developments in relation to the microcomputer in secondary mathematics teaching. It is only fitting to conclude the historical survey by examining the state of play in this field.
2.3.11 Secondary Mathematics and the Microcomputer

Although there are indications that the Department of Education was aware of developments in computer education since the early 1970's, it was not until 1979 that the Minister of Education officially announced that computer studies was going to be incorporated into the mathematics programme [69]. The following year saw the introduction of an optional section on Computer Studies in the Leaving Certificate mathematics programme as an interim measure in order to enable pupils to become familiar with the use of computers at an elementary level. It did not form part of the Leaving Certificate mathematics examination but students who performed satisfactorily could obtain a statement to that effect from the Department of Education. Teachers were asked to include as part of their computer syllabus such aspects as everyday applications, structured diagrams, problem analysis, one high and one low-level language, together with various programming concepts. Pupils were asked to write and run ten programmes and project work was also encouraged [43]. In 1983, the Department of Education sought the views of the school and teacher organizations on the future place of Computer Studies as an optional component of a revised mathematics programme [58]. Subsequently, a syllabus committee was established to produce a Computer Studies syllabus for the new module for junior cycle students. Within six months, a Computer Studies syllabus for the new module was published by the Department of Education, based on the work of the syllabus committee, and schools were invited to participate from the beginning of the 1985 - 86 school year. As in the case of the Leaving Certificate option, the module did not form part of the Intermediate Certificate examination and no statements were issued to pupils who took the mathematics programme, although the memo issued to school authorities in August, 1985 stated that the module could be taken as part of an approved syllabus in mathematics at junior cycle [70].

Reports of the computer studies syllabus committee meetings serve to illuminate factors which gained prominence in the debate leading to the emergence of the computer syllabus for
the junior cycle. For not the first time, content assumed a prominent position. Indeed the syllabus is presented as a list of content topics and sub-headings and little by way of explanation or clarification [43]. Although some notes are appended to the syllabus to indicate depth of treatment, pedagogical guidance for the teacher is conspicuous by its absence. Moreover, content issues were decided prior to the determination of aims and objectives. The latter were added in as a matter of form at the end of the deliberations. Thus, it is hardly surprising that arguments still persisted in the final syllabus committee meeting, for the committee had failed to clarify explicitly for itself what purpose(s) the syllabus was intended to serve. No mention is made of calculators or as to how the module might have linked up with the computer studies option at Leaving Certificate level. Submissions by a number of computer educationalists from the third level sector also had an impact on the final version of the syllabus [71],[72].

In common with the mathematics innovations, no specific textbooks were issued by the Department of Education and no consideration was given to the possible advantages which might have been gained from well-planned pilot studies. In-service courses of one week's duration were made available but during summer vacation time. The latter tended to focus an inordinate extent on programming languages, especially PROLOG with virtually no explanation/discussion on teaching methods or pedagogical strategies for the teacher in the classroom. This judgement is made by the author after having attended one such computer studies in-service course of one week's duration in Maynooth College, August 1985. In reality, the Computer Education Society of Ireland (CESI), - a voluntary organization of teachers founded by Professor A.C. Bajpai in 1973 - played a central role in the training and education of teachers in computer education. The proactive role which CESI adopted throughout the 1970's and 1980's was not confined to in-service alone. It helped in the identification of needs, the construction of syllabi and in the provision of tangible support especially through its journal and software library [73]. In a sense, the role of CESI was analogous to that of the Irish Mathematics Teachers' Association during the reform measures of the 1960's.
No developments have taken place since 1985 apart from the issuing of a sample paper in September 1987. The lack of attention to matters of pedagogy has been recognized by the Department of Education. In an explanatory note accompanying the list of in-service courses (for the summer of 1988) to post-primary schools, mention is made of the scarcity of suitable pedagogical aids for the proper teaching of the syllabus [74]. The Department’s response is merely a promise to have classroom notes, comprising one year’s work, available at all computer in-service courses in 1988.

Significantly, no mention is made in either the junior or senior cycle syllabus of how the microcomputer can be used to improve the learning and understanding of mathematics. A cursory glance at developments elsewhere indicates the lack of searching analysis and vision which has underpinned developments in computer education in Ireland. In the U.K., for instance, a number of reports have highlighted the very great implications which the advent of the microcomputer has posed for the content and teaching of the mathematics curriculum [75], [76]. One of these reports identifies fifteen important effects of the microcomputer for secondary school mathematics [75]. The same report (p.4) has this to say regarding the implications of the onslaught of the microcomputer for mathematics teaching [75]:

The microcomputer is opening up new methods of learning mathematics and already bringing about subtle shifts in teaching emphasis. Microcomputers in schools can generate excitement and inspire motivation; microcomputers have tremendous potential for the better learning of mathematics.

Such areas as statistics, probability, calculus and geometry and how the teaching of these might be affected by the microcomputer have been debated and suggestions made. Attention has been focused on the enormous problem of motivating teachers to find the considerable time and energy necessary to harness and implement the new possibilities offered by the microcomputer [75]. Regrettably, Ireland has not had the benefit of such wide-ranging debate and analysis.
in the development of computer education. In the absence of a national initiative, global and central issues have remained untouched. Moynihan et al [77] sum up the official position in Ireland cogently as follows:

The official position has been positive but is distinguished by the absence of a coherent policy or plan for Information Technology in Schools. It can be described as a piecemeal approach.

Thus, it is hardly surprising that the role of the microcomputer in mathematics education has received insufficient attention. The "piecemeal" approach to computer education is hindering real progress in this important field. Yet, as the next chapter argues, this need not be the case.

At this stage, it is both necessary and worthwhile to draw together some of the threads of the discussion which this historical account has attempted to signpost: to look at the successes and failures of the period surveyed.

2.4 Summary of problems in Secondary Mathematics in Ireland

This historical survey has attempted to highlight the significant developments which occurred in secondary school mathematics in Ireland. In the process, a number of problems were identified. On the positive side, mathematics courses have responded to international developments and since 1965, it is possible to detect an increased level of teacher involvement in the field of syllabus design and construction although the response from the general body of mathematics teachers continues to be disappointing. The mathematics courses have been subjected to revision on a reasonably regular basis. The most recent revision of the Intermediate mathematics syllabi has recognized the need for more than two mathematics courses to fully meet the demands of society in providing students with the necessary mathematical skills for the future.
On the negative side, it was pointed out that the teaching of geometry presented a problem. The most recent changes in the Intermediate mathematics courses have taken cognizance of the need for reform in this area and, as such, are to be applauded. Since the foundation of the State, a supply of suitably qualified mathematics teachers has caused concern. Over the years, the Department of Education has failed to address the problem of providing an adequate and sustained national initiative in this area and genuine pedagogical reforms in secondary school mathematics will remain impossible to achieve. The innovative attempts in Thomond College of Education to train mathematics teachers are certainly refreshing.

The innovative attempts to reform mathematics since 1964 have been characterized by a lack of attention to a number of important features. The failure to base reform measures on a systematic inquiry and investigation into mathematics teaching, a lack of adequate in-service training and support services for mathematics teachers, inadequate consultation with the educational partners including pupils, the absence of properly controlled pilot studies and pedagogical aids all constitute serious shortcomings and militated against successful innovation. Ironically, only the mathematics courses which were introduced in 1925 - 26 had the benefit of an investigation into the aims of mathematics teaching when all the educational partners had a significant influence in affecting the final version of the syllabi. Thus, real difficulties are discernible in retrospect. The evidence suggests that major attempts at curricular reform in mathematics in Ireland in the period 1970 - 88 have failed. Curriculum development was essentially a piecemeal process, relying to an inordinate extent on the initiative and goodwill of only those schools and teachers who displayed an interest in helping to achieve a more balanced mathematics curriculum. The failure of some of the pilot projects in mathematics described earlier to achieve implementation on a widespread scale demonstrates the formidable difficulties of achieving worthwhile curricular change while operating on the periphery of a centralized system of education.
In spite of all the reform initiatives, change has been relatively marginal in the classroom practices of the vast majority of secondary mathematics teachers. Syllabi may have been modified but pedagogical methods and educational philosophy (or lack of it) remained essentially the same. Indeed, the picture conjured up of the mathematics teacher during the innovative reforms is a fatalistic one. On each occasion since 1964, the reform measures were imposed from the "top-down". Mathematics teachers were at the end of the implementation process - powerless participants who had no say in decisions which were to affect their very own reality in the classroom. Pedagogically, they were insufficiently trained to teach the mathematics courses effectively and yet expectations were high. Although the situation did improve somewhat after 1965 with teacher representation on the mathematics syllabus committee, input from the general body of mathematics teachers was poor. For the most part they adopted a passive and subservient role, reinforced by a belief that the ordinary teacher could not affect curriculum decision-making - this was and always had been the domain of the Department of Education.

Significantly, there existed no appraisal or evaluative procedure to monitor both the intended and unintended effects of the innovations introduced. Such an appraisal mechanism would have served to identify defects and deficiencies at a much earlier stage. Accordingly, there may be grounds to fear that new developments to be attempted in the future will only add to the list of failures.

A number of other criticisms can also be made. Firstly, the survey has shown that insufficient attention has been given to the task of determining a comprehensible and defensible set of mathematical aims and objectives, taking cognizance of pupil abilities. This would have guided the selection and organization of content and provided a benchmark for future evaluative work. The recent attempt by the Curriculum and Examinations Boards has not improved the situation. Secondly, there has been a serious failure to realign the mathematics
syllabi at first and second level and transition problems remain for the present. Thirdly, the mathematics courses themselves are the subject of considerable dissatisfaction. These include their abstract nature, their heavy emphasis on concepts and notation, their lack of relevance to everyday life and reduced emphasis on traditional skills. Consequently, it is understandable that attitudes to the subject will suffer among those weaker pupils who have no academic aspirations. Finally, the role of the microcomputer in the improvement of mathematics teaching and learning has not been appreciated. The extent to which the availability of microcomputers should change the content of what is taught or the relative stress which ought to be placed on different topics within the mathematical syllabi has yet to be debated and a national initiative implemented.

In general, no searching analysis has been made of the fundamental role of mathematics in the curriculum. It was pointed out that the recent CEB discussion document on mathematics failed to address a number of central issues. Moreover, little consideration was given to the problem of teaching mathematics apart from an attempt to list particular problems in the teaching of the subject. There is an assumption that the teaching of the subject may be satisfactory but that other elements require attention such as the aims, content, texts, and transition between primary and post-primary school. Important as these issues are, both this chapter and the succeeding one would question the validity of such a tacit assumption in the sense that a major problem with mathematics in post-primary schools may centre on the teacher in terms of inadequate pre-and post-service training, isolation, acquiescence and an acceptance of the status quo, poor professional standing and increased pressures especially accountability. For those mathematics teachers in post-primary schools who were hoping for an improvement together with a searching analysis of the problems involved in the teaching and learning of mathematics, the discussion paper is a major disappointment as is the failure to match the recommendations with implementation.
In conclusion, this historical survey has indicated that successive Ministers of Education never fully appreciated the scale, complexities and implications of curricular reform in secondary mathematics, or if they did, they chose to ignore the resource implications of the ideals expressed at classroom level. The next chapter elaborates on a number of key mathematical issues which this chapter has signposted together with highlighting more promising avenues of development for the future.
CHAPTER 3

KEY ISSUES IN SCHOOL MATHEMATICS EDUCATION: THE IRISH CONTEXT

3.1 Introduction

This chapter seeks to analyze and elucidate some major issues which the previous chapter has identified. The sole purpose of the following analysis is to provide insights and information which will assist future debate and decision-making on crucial questions facing mathematics educators in Ireland. Possible avenues for the future are explored together with highlighting probable implications. Although the concern is with the Irish context per se, it is suggested that the ensuing debate and dialogue does have a wider appeal. The issues subjected to scrutiny are not specific to Ireland. A primary reason for this global appeal is the extraordinary uniformity and status of mathematical syllabi throughout the English speaking world. Thus, the understandings gained are offered as a useful framework for educational administrators, ministries of education, schools, mathematics educators and teachers in other countries, within which further discussion and analysis can take place in a productive manner.

3.2 The professional position of the secondary mathematics teacher

The previous chapter has pointed towards a number of constraints which impinge upon the professional standing of the Irish secondary mathematics teacher: the lack of consultation and participation in educational policy and decision-making at national, local and school level; the paucity of opportunities to engage in reflective and deliberative research work; adherence to a centrally prescribed mathematics syllabus; inadequate pre- and post-service training and above all a lack of awareness by
mathematics teachers themselves of the factors which have shaped and controlled the future of their mathematics teaching. At a time when mathematics teachers are expected to respond to new challenges, it is appropriate to examine more closely factors which adversely affect the professional standing of the secondary mathematics teacher and thus his ability to respond usefully to new demands.

3.2.1 Factors adversely affecting the professional status of mathematics teachers

It is possible to identify a number of factors which adversely affect the professional status of secondary mathematics teachers. Firstly, structural problems present a contextual constraint when considering principles of professional development for mathematics teachers. The hierarchical nature of authority structures in Irish post-primary schools is inimical to accommodating teacher participation in professional issues. For the most part, the secondary mathematics teacher is an inactive and docile functionary working within hierarchical and autocratic structures where meekness, obedience and subservience are the order of the day. No forum exists which would facilitate a healthy questioning of the status quo. Leonard [78] puts this cogently: (p.22)

In much of the second-level teacher's work, his position is that of a powerless functionary working within authoritarian structures. He follows rules laid down by others. The system's ideology can be described as one of teacher control.

It is doubtful if mathematics teachers have assimilated the implications of hierarchy. Systematic analysis of teaching, exploration of alternative approaches, analysis of individual teaching and learning problems, and the generation and testing of possible solutions are all activities that neither occur at the individual teacher level nor among colleagues in Irish secondary schools. Collegial interaction is not a common part of teachers' professional behaviour. This "closed door" mentality [79] that apparently locks mathematics teachers away into their classrooms appears to be the product of the
institutional structure in which teachers work and the training they receive.

Secondly, the actual work profile of the secondary mathematics teacher points towards a restricted professional self-image. A mathematics teacher who has to teach 150 -200 pupils each day has little time to attain admirable aims and aspirations, to reflect on his teaching, to prepare instructional materials, to inspect a variety of alternative approaches or to work with colleagues on innovative mathematics programmes. Mathematics teachers do not have a budget for purchasing materials or travelling. They lack discretionary time for working with colleagues or students. In short, their work regime inhibits their development as "reflective practitioners". When mathematics teachers are further harassed by lunchtime duties and administrative chores, then morale deteriorates. For the most part, the restricted self-image is of a subject specialist who prepares his pupils for success in state examinations in a highly centralized system of education. The scenario serves only to diminish the mathematics teachers' professionalism. Admittedly, this is a problem shared with teachers of other subjects, but that does not remove the issue as a source of concern. Indeed in the U.K., the opportunities that dissatisfied mathematics teachers have to enter better-paid and higher-status fields have made the retention of experienced and capable mathematics teachers an especially severe problem [68].

Thirdly, there does not exist a proper promotional and career structure for secondary school teachers. The existing "Posts of Responsibility" system does not facilitate teacher demands for the creation of genuine promotional opportunities. The act of teaching mathematics becomes downgraded as young mathematics teachers learn the demoralizing fact that they do not have to perform any better to attain a promotional post. Teachers' unions have made submissions in this area, the most recent being in the context of the 1980 salary review [80].
deliberative and innovative research work at national, local or school level.

Fourthly, the structure of the supporting services provided for Irish mathematics teachers to engage in professional activities is fraught with deficiencies. There are few teachers' centres and none specifically for mathematics teachers. There exists no mathematical advisers for teachers on a regular basis. The paltry provision for in-service education in the overall budget of the Department of Education (.004%) is a clear indication that the Department of Education has not acknowledged what actually constitutes even a minimum basis for a system of in-service education for mathematics teachers. In most British secondary schools there is an identifiable unit called a mathematics department, consisting of those teachers who teach mathematics for all or part of their time. The management structure within the department determines to a large degree the professional perspective and stance that is possible for an individual mathematics teacher. New ideas and day-to-day problems are often explored and the problem solving capabilities of the mathematics teacher are enhanced. Staff development courses are a common feature within the programme of the mathematics department. In Ireland, the formal concept of a mathematics department does not exist in post-primary schools. This can be attributed in part to the failure to take management education seriously in Irish secondary schools (see Chapter 2). School principals have failed in their responsibility to promote dialogue and to provide opportunities for thinking about teaching. It is difficult to expect the concept of a mathematics department to take root when school review and evaluation are not normal tools of in-school planning and review. As a result, few chances exist for secondary mathematics teachers to be proactive and to gain experience in the practical skills of curriculum development resulting in constricted professional growth. In Hoyle's [81] terms, mathematics teachers adopt a "restricted professionality". The pre-service training of secondary mathematics teachers, as revealed in Chapter 2 points towards a limited preparation for his professional
career. Elliott's [82] three levels of professional development suggest that professional development and teaching quality will be improved through deliberation and action-research. Yet, teacher education courses in general do not promote a pedagogy which places a high value on reflection, collaboration and on the pedagogical knowledge gained through teaching experience. Most secondary mathematics teachers who are currently teaching were trained at a time when the discipline of self-appraisal was largely unknown in centres of education. Although the picture has improved, the pre-service training of mathematics teachers needs to incorporate a greater analysis of fundamental issues such as the fundamental purpose(s) of education and syllabus justification. Moreover, practising mathematics teachers at present play no role in the accreditation of pre-service courses.

Finally, the problem of the professional status of mathematics teachers has been exacerbated by the fact that no Teachers' Council exists which would enhance the professional image of teachers by assuming responsibility for the maintenance of professional standards. Teacher unions have been united in advocating the formation of such a Council [83]:

The achievement of professional self-government will further strengthen the position of teachers and in the process improve the quality of the educational service.

In recent times, a climate of economic recession has adversely affected professional status. The optimism and somewhat euphoric social climate of the sixties has been replaced by the hard edged and ruthless social attitude of the eighties. The response of the Irish government has been to indulge in monetarist policies. The years 1983 - 1988 have witnessed five years of unrelenting government cutbacks in post-primary education, which when combined with voluntary redundancy, involuntary redeployment, an increase in teacher stress and discipline problems and the failure to provide the necessary resources for curricular and examination reform clearly indicate serious concern that the teaching profession and
education in general are under siege. It is questionable to what extent mathematics teachers themselves are aware of the cumulative and disempowering effect of the forces and factors which shape and constrain their professional perspective. Moreover, evidence from the previous chapter pointed overwhelmingly to an inactive and acquiescent role on the part of mathematics teachers in curriculum decision-making. It was noted that even recent initiatives in Irish education have been overly concerned with structures, subject groupings and assessment issues. Matters of pedagogy received insufficient attention and no evidence emerged which would indicate that both principals and teachers are prepared to adopt a new professional perspective to their work.

Thus, whether through a combination of a lack of confidence, autonomy or a lack of awareness of forces and events which shape their professional status, mathematics teachers are not in control of the future of their mathematics teaching on their own behalf or that of their students. Even today, there is a pressing need for a process designed to help mathematics teachers to adopt a new professional perspective, to regain control, to restore their decision-making capabilities and to equip them with a belief in their own autonomy. The necessity for such empowerment is evident from the meagre number of submissions received from practising mathematics teachers in the construction of the recently revised mathematics syllabi at Intermediate certificate level. There is a great need to take stock of the profession and to indicate new avenues for exploration.

3.2.2 New avenues for exploration

Attempts at improving the professionalism of mathematics teachers must be seen in the overall context of the public perception of teacher professionalism in general. There is a persistent reluctance to grant undisputed professional standing to teaching. It is often held that the
term "profession" is a misnomer. Hoyle [84] has claimed that the traits of intuition and common sense have been dressed up as being part of the esoteric knowledge claimed by the traditional professions. In the Irish context, Hogan [85] states:

The robes and rituals of schooling merely give a pretentious air to something which, it is said, is after all a matter of common sense and experience - on-the-job.

In the academic world, teachers' professionalism lacks credibility and their work is undervalued. Lacey [86] in the U.K. points to the tenuous hold that teachers have on their professionality and goes on to suggest that documents such as Teaching Quality [87] tend to undermine it. The Royal Society [88], in the mathematical context, has attempted to define the term "profession" by virtue of three characteristics:

(1) the special knowledge and training of its members
(2) its corporate character
(3) a measure of self-determination on the part of its members.

Teachers do not have the self-determination and autonomy that accepted professionals are said to have since they work in bureaucratic organizations, unable to reject clients or demand fees. Unlike traditional professions, there is no generally accepted code of conduct or set of professional ethics among teachers and the loose structure of teachers' employment results in there being no mechanism for enforcing discipline or for controlling entry into the occupation. Indeed, in the Irish context, the teaching profession (including mathematics teachers) can be more easily identified by their low level of professional authority and autonomy combined with acquiescence, traditional routines and isolation. Conscious that the concept and perception of professionality is problematic, the author offers the following basis for the improvement of professional status with particular reference to mathematics teachers.
Firstly, it is vital to upgrade the status of the core professional activity of teaching. The pedagogical knowledge that mathematics teachers can gain from their own experience and action-research needs to be valued more by those offering and providing teacher-training and in-service courses. The role that self-appraisal and the discipline of constructive self-criticism can play in improving the professional status of mathematics teaching is considered later in this study in detail. School principals have an obligation to promote dialogue among mathematics teachers. To facilitate this, opportunities must be available for mathematics teachers to meet and discuss issues. At another level, the status of mathematics teaching can be improved by establishing an adequate career structure for mathematics teachers. Expertise in mathematics teaching must have an impact on career prospects. Thus, a proper promotional and career structure needs to be set up to attract and keep mathematics graduates of highest quality. In addition, the new structure needs to discriminate positively in favour of such presently neglected areas as curriculum development, staff development and structured Mathematics Departments.

Secondly, professional structures which are real must be introduced to achieve professionalism in mathematics teaching. A mathematics department in every post-primary school has the potential to improve the professional life of mathematics teachers. The realization of this potential is conditional on serious consideration being given to the need for management education both for school principals and the newly appointed Heads of Department. The idea of mathematical advisers deserves important mention in the pursuit of improved professional structures. By adopting a facilitative role they could bring mathematics teachers together to work on a common task, to help render the familiar strange or by putting a mathematics teacher faced with a particular problem in touch with others who have encountered the same problem and have come up with solutions. In the process, the problem-solving capabilities of mathematics teachers can be considerably
enhanced. At present, the concept of mathematical advisers could find accommodation in redeployment negotiations. Suitable redeployed mathematics teachers could be productively employed in this new role after first engaging in a period of intensive training. The existence of centres for research in mathematics education could also have an impact on professional status. Formal networks of centres such as IREM's in France have shown how useful such agencies can be for in-service education and research within a highly centralized system. There is a pressing need to establish a professional planning body to co-ordinate existing resources and plan the development of a comprehensive programme of in-service education. In 1980, the Department of Education established a Committee on In-service Education [89]. There was a great recognition among the Committee of the personal and professional needs of the teacher. The Committee's report made numerous and very valuable recommendations, which if implemented would have greatly advanced the claim of teachers to professional status. It recommended the establishment of a National Council for In-service Education (N.C.I.E.) and also Local Councils (L.C.I.E.). Representation on these Councils was to be heavily weighted in favour of practising teachers. Teachers' Centres, the inspectorate and institutions of higher education were envisaged as playing vital roles in the administration of these Councils. Alas, nothing has come to pass.

Thirdly, there is a greater need for autonomy in the teaching profession. Mathematics teachers do possess a valuable and specific competence. The latter ought to be codified into a coherent body of principles and must be relevant to the actual problems of living. If the teaching body asserts its right to greater autonomy then educational innovations will be nurtured and advanced. Out of such autonomy will grow structures which will facilitate all those engaged in education to respond over time to the changing needs of pupils and society.
Finally, mathematics teachers must be accountable for their actions as professionals. In this respect the establishment of a Teachers' Council could provide a mechanism to assume responsibility for the maintenance of proper professional standards through the development of professional conduct codes. The Council ought to consist of a majority of serving teachers, nominated by their unions, together with representatives of management, third level and the Department of Education. A Teachers' Council must identify and safeguard educational practice and must pursue and correct violations of such practice. Thus, the rights of teachers would be protected against undue outside interference whilst at the same time safeguarding the legitimate rights of society. The difficulty lies in defining, in a courageous manner, what constitutes an acceptable code of practice and the purpose(s) this code should serve. For mathematics teachers, two worthwhile goals ought to be the improvement of practice and a commitment to that improvement together with the development of skill, insight and critical reflection which must be couched within a framework of theoretical understanding.

Certainly, a great deal of mathematics teaching and school organization has no theoretical substructure and perhaps this partly explains why many non-professionals believe they have the right to define a teacher's function. Thus, built into the code is an explicit assumption that the mathematics teacher has a professional obligation to take care of his professional development.

This section has attempted to put forward what the author believes to be necessary prerequisites for building a professional foundation for mathematics teachers. It is not suggested that the ideas expressed are exhaustive. Furthermore, financial and other resources will have to be made available to implement the suggestions offered. It is a truism to state that society will only get the "profession" it pays for.
3.3 The place and aims of secondary mathematics

3.3.1 The present position

The historical survey of the previous chapter revealed that the introduction of mathematics objectives for the first time in 1973 and 1976 for the Intermediate and Leaving Certificate mathematics programmes respectively was a haphazard process. Mathematics teachers were not given the opportunity to discuss the implications of the new objectives. No specific texts or teaching aids accompanied the new innovation. In short the management of the introduction of the innovation was characterized by serious breaches of proper curriculum procedure. As the objectives have withstood the passage of time, a closer analysis is appropriate. It is proposed to examine in detail the objectives for the Intermediate Certificate mathematics syllabus. The seven objectives state that a student should [43] : (p.40)

(1) acquire skill in computing with understanding, accuracy and efficiency
(11) acquire an understanding of mathematical facts and concepts
(111) understand the logical structure of mathematics and the nature of a proof
(1V) use mathematical concepts and processes to discover generalizations and applications
(V) associate mathematics with applications from everyday life
(VI) discover attitudes that lead to application, confidence, initiative and independence
(VII) develop study habits, reading skill and vocabulary essential for independent progress in mathematics.

As these new objectives have withstood the passage of time to the present day, a closer analysis is appropriate. With the exception of objective (VI) the aims are framed with particular reference to the learning of mathematics and can, therefore, be categorized as mathematical aims. It may not be appropriate to attach very much importance to the order in which they are presented, but it is interesting that the acquisition of "skill in computing" without (as is apparent
from the syllabus) the aid of machines should appear as the first item on the list. Certainly the compulsory problem type questions in the new examination papers reflected a fresh emphasis with social and practical arithmetic. This can also be attributed in part to the "back-to-basics" movement which had been concerned about the effect of the modern mathematics on computational ability. Objectives number (11) and (111) would seem to be closely related depending on what is meant by "mathematical facts". A fact is a true statement and accordingly mathematical facts can be thought of as being mathematical statements which are true. They would include for example the axioms, definitions and theorems embodied in the course. It is usually not until the end of second year or third year that the proofs of theorems are learned. In the Pass course, the formal learning of fifteen theorems is required, while in the Honours course, twenty eight including the theorem of Pythagoras are required. It is debatable whether learning these theorems promotes understanding of the nature of a proof, which is one of the aims of the activity as seen by those who designed the curriculum. It is also questionable at any rate, whether this aim has any meaning for children aged between twelve and fifteen years. It is assumed that the word "proof" means mathematical proof and while this may narrow the area of inquiry and eliminate some of the philosophical issues of proof, in a more general context it would still seem to demand an intellectual capacity beyond that which most children of this age range possess. It involves the consideration of the relative merits of different proofs and this would seem to be fraught with difficulties when little attention is given to the need for proof in the first place.

The designers of the syllabus perceived the overriding aim to be that [43] : (p.40)

students should be able to marshall their knowledge so that they could apply it to solve problems.

This is an extension, as it were of objectives (IV) and (V) in so much that it involves the application of mathematical
knowledge. The inclusion of the word "could" in the statement is difficult to understand and seems to indicate a lack of clarity as to the relationship between mathematics and problem-solving. There are two dimensions to this issue. On the one hand there is the question as to the role of mathematics in solving problems and, on the other hand, the place of problems in learning mathematics i.e. the didactic uses of problems. The way in which the aim is stated seems to indicate a lack of commitment to the latter although both would appear to be complimentary. It is implied that mathematics teaching should aim at developing the ability to recognize which sort of problems are amenable to mathematical methods. This can only be done if children actually experience mathematics as an activity of solving problems, and this does not mean solving problems according to fixed rules. It is the case, however, that it is just these types of problems that appear annually on the examination papers in mathematics.

Objective (V1) is different from the others in a fundamental way. Firstly, by introducing attitudes or dispositions it enters the affective domain. Secondly, the outcome of the desired attitudes is concerned with the development of the intellectual qualities of a general nature in the sense that those mentioned i.e. confidence, initiative and independence are attributes which education in general seeks to develop. They are closely related to intellectual maturity and can be conceived as the outcome of the educational experience of the individual. They have their basis in the degree to which the learner has mastered certain standards or complied with certain expectations. Thus, they are dependant upon the experience of success which is a necessary condition for their development. This, of course, raises the issue as to what is to count as success. If it is to be determined or measured by performance in examinations, success is denied to a very high proportion of children. This can be gauged from the annual statistical reports of the Department of Education which indicate on average, failure rates of twenty to twenty-five per cent for Intermediate Certificate mathematics. This,
unfortunately is almost inevitably the outcome when all students are expected to follow a course of mathematical studies, the content of which is determined by what is to be examined in the Intermediate examination. This is likely to persist so long as what is to count, and what is actually seen as success is determined in this way.

It is also stated that mathematical education should develop attitudes leading to "appreciation". This does not appear to be very helpful as the object of the appreciation is not specified. It is non-behavioural. It may thus refer to anything from awareness of the significance of mathematics in scientific development to a realization that mathematics is the creation of geniuses. In both of these instances, the term is used in a positive sense and it would seem from the context in which it appears that this is the meaning which the authors intended to convey. It can thus be taken to refer to the development of attitudes favourable to the further study of the subject, but whether more than this is implied is not quite clear.

This analysis indicates that there is some truth in the comment in the 1956 report [44] concerning the difficulty in specifying aims. This is manifest when one attempts to interpret particular aims, upon which the problem of vagueness is encountered. In addition, the emphasis appears to be placed, either directly or by implication, on what might be described as the instrumental aspect of mathematics i.e. its use in everyday commerce and other subject areas. Objectives number (1) and (V) belong to this category of aims. In contrast, the value of mathematics in the intellectual development of the individual is only directly referred to in objective number (VI).

More recently, attempts by the Curriculum and Examinations Board to justify the place and aims of secondary mathematics has been disappointing (see Chapter 2). The consultative
document on mathematics [65] did attempt to specify aims and objectives for mathematics but they are so general as to be of little value in the development of worthwhile mathematics programmes. In general, the analysis has shown that insufficient attention has been given to the task of determining a comprehensible and defensible set of mathematical aims and objectives. The objectives constitute desirable goals without any genuine commitment to match the rhetoric by way of implementation. There is an urgent need for an analysis of the fundamental role of mathematics in the secondary school mathematics curriculum which takes cognizance of pupil abilities and the implications of a technological society.

3.3.2 The need for a new analysis

The high status given to mathematics is not peculiar to Ireland. The universal status of mathematics has given the subject a privileged position in secondary education. However, this very same status implies that the teaching of mathematics absorbs a large proportion of finance, teachers and time. Thus, it is of vital importance to reappraise the place and aims of mathematics in Irish post-primary education by addressing such fundamental questions as "why teach mathematics at all?", "how does mathematics relate to general educational goals?", "what is the intellectual worth of learning mathematics?" or "what is the place and aims of mathematics in a technological society?". Solutions to these and other important questions facilitate the justification of the place and aims of mathematics in secondary schools.

In what ways can mathematics contribute to general educational goals? Hitherto, the role of mathematics in cultivating reasoning power received an unrivalled position. A more appropriate aim is to develop 'critical power' that will enable pupils to develop a critical attitude to numerical
information presented to them in this information age. In an age of uncertainty, mathematics has a role to play in the exemplification of certainty. This has implications for the teaching of secondary mathematics. It implies that pupils ought to experience enough mathematics to appreciate this 'certainty' value. In addition, the teaching style should reflect this by helping and encouraging pupils to acquire such convictions for themselves. Mathematics can also provide aesthetic pleasure if the experience facilitates this goal.

Unfortunately, such pleasure is denied to the vast majority of secondary mathematics students in Ireland. The satisfaction gained is primarily extrinsic; learning mathematics is essentially perceived as a means of satisfying 'entry' requirements for third level or of gaining necessary qualifications for employment opportunities. Consequently, the teaching of mathematics has become seriously distorted.

The low number of Leaving Certificate students who receive a Grade A (85% or more) in the Honours course gives the impression that mathematics is difficult. This must be countered to allow the subject to become accessible and more enjoyable to a greater proportion of students. Perhaps such an attitude partly explains why calculators were only permitted in the senior cycle mathematics programme as recently as 1985 and the continuing reluctance to allow their use in the junior cycle. Students ought to experience the more aesthetic side to mathematics, to appreciate the power which mathematical knowledge and understanding can give them in the solution of their own problems and decision-making.

Mathematics teachers should give their students examples of the ways in which mathematicians search for common structures, engage in problem-solving or simply talk about the subject. Furthermore, provision should also be made for mathematics teachers in the sense that they too should be able to obtain 'pleasure' from the mathematics curriculum which they teach.

The service role of mathematics to other disciplines will continue to remain an important goal in such subjects as biology and geography which are becoming more quantitative, thereby providing new opportunities to display the power of mathematical applications. Mathematics must also serve to equip students to cope with mathematical demands and problems.
which they will meet out of school.

Traditionally, the mathematics curriculum has been content-orientated in preparing pupils for their future lives. An alternative view which perceives mathematics as a set of processes is possible where the task of the mathematics teacher is to help students to learn how to 'mathematize' by providing the appropriate experiences. Within a computer-orientated society, such processes would include classifying, comparing, ordering, abstracting, symbolizing and generalizing. This radical alternative might not be an acceptable basis to the Department of Education and the public who are conditioned to think of mathematics in terms of content and techniques. It would require new sources of teaching material, new teaching skills and a reorientation of mathematics teachers' perspectives. Nevertheless, mathematics educators have argued for an increased emphasis on mathematical processes [1].

The familiar secondary school mathematics curriculum was developed in Western Europe in the aftermath of the Industrial Revolution. Before Ireland achieved independence, this universal mathematics curriculum had already been imported and adopted. However, those who designed the mathematics curriculum had only a small academic elite sector in mind - those who could afford to pay. In 1967, with the advent of 'free' post-primary education, mathematics became available to vastly increased numbers. It is now a compulsory subject for all junior cycle pupils. This move towards "compulsory mathematics for all" introduced a major problem. While the number of pupils taking mathematics increased dramatically, the mathematics curriculum has remained essentially unchanged (see Chapter 2) from that which was planned for a small elite academic group in earlier years. This situation has culminated in unacceptably high failure rates in the public examinations as the mathematics curriculum remains unable to provide relevant, interesting and exciting mathematics for the vast majority of secondary pupils. Valuable teacher time has
been wasted in teaching a style of mathematics to students who have effectively given up on the subject and many students continue to experience frustration and discouragement. In effect, 'compulsory mathematics for all' has given insufficient attention to strategies for differentiation. The recently revised Intermediate mathematics syllabi have utilized a differentiation strategy based on content. It is proposed that weaker pupils follow syllabus C which is a watered-down version of that studied by average ability students who will take syllabus B. The latter, in turn, cover essentially the same topics as their more able counterparts who follow syllabus A but not to the same level of complexity. It is doubtful if this strategy alone, with its over-emphasis on 'content' will provide weaker pupils with a serviceable mathematics curriculum unless matters of pedagogy receive the necessary attention required. This will require resources and in-service education. It is also disheartening to think that the possibilities for individualized learning, which the advent of the microcomputer has brought, have not been harnessed in the quest for relevant differentiation strategies. It is important that the arrival of new technology should not be solely reserved for extension activities with the more able.

The aims of secondary mathematics should reflect and contribute to the Irish culture. At present, very little reference in secondary mathematics is made to the history of Irish mathematics and the achievements of Irish mathematicians. An increased emphasis on this aspect fosters a sense of pride and of 'ownership' of mathematics, reinforcing students' confidence and relating the subject to history and to national tradition.

The previous chapter revealed that, in Ireland, the aims of secondary mathematics at the junior cycle do not complement the stated goals of the primary school mathematics programme. The two programmes are out of alignment with each other as the two programmes were drawn up independently of each other. One
of the aims of the primary school mathematics programme seeks to prepare students for further work at post-primary level [62]. A very proper aim of a post-primary mathematics programme might accordingly be to ensure a well-ordered and gradual transition from the more practical work of the primary school to the more abstract approach at post-primary level.

The present set of aims for mathematics at Intermediate certificate level does not address the interests of students who drop out of secondary education prematurely. Approximately five and a half thousand pupils are still leaving the Irish education system each year without any certification [90]. For these pupils, the questions which require responses are: "have their years of study of mathematics been entirely wasted?" and "has their experience of compulsory mathematics been of a set of rules and unexplained procedures?". Certainly, few students in their final year of formal mathematics education require more technique; they are better facilitated by a mathematics curriculum that seeks to help them to appreciate the role and power of mathematics in its applications at the level which they have reached. At present, there is an enormous waste of human material resources in those who drop out prematurely. If the situation is allowed to continue, the implications are unsavoury. Society will continue to consist largely of people whose attitude to mathematics is dominated by a sense of failure, and who find it impossible to learn more mathematics should it prove necessary in the future. It is unlikely that the situation will improve in the short-term. In the interim it is imperative that secondary mathematics is taught and learned in such a way as to give the target group concerned more experience of success. Long-term wise, a compromise strategy would be a modular mathematics curriculum, in which each component of the mathematics curriculum is seen as a module which could extend over a limited period of up to three years.

Finally, this section has not distinguished between the aims
of a mathematics education for girls and those for boys. Strictly, there are no essential differences. Yet, it is important to acknowledge that significant gender differences do exist as measured by participation in the Honours mathematics Leaving Certificate course. Although the annual statistical reports of the Department of Education reflect steady progress in the number of girls attempting Honours Leaving Certificate mathematics since 1961, recent research [91] suggests that marked gender differences exist in participation favouring boys. In 1980, while 93.1\% of girls took mathematics at Leaving Certificate level, only 4.1\% took the Honours course compared to 15.5\% of boys [91]. Although the trend is towards increasing participation by girls the gap at this level is unacceptably high. Hannan [92] has recommended that changes are necessary in the shared attitudes of parents, pupils and teachers to the subject choices made by girls. This is necessary to encourage more girls to study Honours mathematics in senior cycle and thereby improve their participation in certain occupations or in third level education courses for which higher mathematical entry qualifications are required. The research evidence clearly indicates that deeply held traditional ideologies govern the social class and gender take-up of technical subjects in post-primary schools [92]. These ideologies permeate schools' policies on the provision of these subjects, their policies for allocating technical subjects to different categories of students and also the students' own choice of subjects. The provision of Honours mathematics for girls at Leaving Certificate level is inevitably filtered through these ideologies. Although the perfect solution is beyond the capacity of mathematics educators to achieve, there is need for large-scale re-education of teachers, teacher educators, educational administrators, school principals and pupil attitudes. With the impact of technology in schools, caution is required to ensure that the present gender problem is not exacerbated through role assumptions and a tendency to see computing and technical education in general as male-orientated. Otherwise, there is a danger that mathematics too might become a victim of male and female versions of technology in secondary schools. Ireland can look to the U.K.
experience where the problem is being tackled with increasing vigour [93].

This section has attempted to provide a non-exhaustive analysis of the place and aims of secondary mathematics. It should be noted that the previous section suggested that care must be taken to ensure that a defensible set of mathematical aims takes cognizance of the ability of the bulk of Irish secondary mathematics teachers to make the necessary adaptations. The issue of mathematics in a technological society has permeated much of the analysis. However, the ultimate goals of secondary school mathematics are unlikely to be changed by the presence of computers in the classroom and computing will not replace mathematics. Nevertheless, there are likely to be changes of curriculum emphasis in secondary mathematics. The next section seeks to address this aspect and others relating to the issue of the mathematics curriculum in general.

3.4 The content of the mathematics curriculum

3.4.1 The present compartmentalised mathematics curriculum

Mathematics is but one of twenty-six subject 'boxes' or compartments on offer at junior cycle and thirty-three at senior cycle. This compartmentalisation of knowledge has provided a convenient model for secondary schooling. However, the model owes more to tradition than to logic. It has given rise to a rigid and inflexible mathematics curriculum with severe limitations on mathematical learning for the majority of post-primary pupils. The previous section noted that the mathematics curriculum did not change to acknowledge the perceived needs of the less academic pupils. Consequently, motivation to study mathematics for these students has posed a
serious problem for mathematics teachers. Many of these less able pupils appear to have little interest and/or ability in the subject and the sense of failure experienced is reinforced right up to the time they leave school. In addition, many pupils are unable to transfer knowledge acquired in mathematics (which is only one of many 'isolated' subjects) into usable forms in the world outside. The present academic mathematics curriculum has succeeded in colonizing and alienating those pupils of liberal academic expectations.

Thus, it seems reasonable to suggest that another model is required which eschews this abstraction of experience into compartments, providing instead a means for relating knowledge as it is acquired. It is not enough for mathematics teachers to simply put more effort into pointing out relationships between different mathematical topics. The search for alternatives is returned to later in this section.

3.4.2 The influence of examinations and universities on the mathematics curriculum

A very dominant and worrying feature of Irish post-primary education is the detrimental effect of the public examinations on the mathematics curriculum and teaching. Instead of measuring student achievement, examinations dominate the curriculum and distort the learning process. Mulcahy [9] puts it as follows: (p.160)

Pressures for examination success are considerable. The effect on post-primary education is likely to be unsavoury; with success in the examination as the goal to which the teacher aspires, one cannot reasonably expect teaching to be carried on for educational reasons as much as for reasons of examination success.

A salient feature of such examinations is that they require a certain percentage of fail, pass and honours results. This
inevitable stress on the issue of success and failure does not promote the consolidation of mathematical learning or accurately measure the intellectual ability of the student. The lack of responsiveness of the present assessment system has ensured that mathematics teachers and pupils engage in an annual ritual of minutely examining past papers in an attempt to predict the future intention of the examiners' minds.

Thus, the mathematics curriculum has been forced to conform to the needs of an examination system which has remained largely unchanged since its origin in the passing of the Intermediate Act in 1878 and its subsequent modification by the amended Intermediate Act of 1924. Moreover, it has ensured that pupils have been prevented from gaining an understanding of mathematical knowledge in its various forms. Examination teaching has concentrated instead upon the learner's acquisition of skills and techniques. Outputs (products) are perceived to be more important than pupil experiences (processes). Inevitably, then, the type of mathematical knowledge which most pupils construct will be the knowledge required to obtain success in the public examinations. The situation is not helped by the view of mathematical knowledge which parents and employers hold, which is often restricted to a knowledge of facts and a few well-defined skills. The present mathematical syllabi list desirable skills and concepts in an itemized fashion with the consequent danger that mathematical knowledge may thereby be atomized and, in a sense, finalized. This could lead to a situation where students would later experience dissonance when told that the concepts of 'function' and 'variable' are presently changing and evolving due to the technological revolution. Such forms of mathematical knowledge as 'how to' apply mathematics, 'how to' generalize or 'how to' justify receive little or no attention at present. There is a need therefore to ensure that any new assessment procedures developed extend the range of 'assessable' knowledge so as to cover all the various types of mathematical knowledge. The onslaught of microcomputers for example emphasizes the need to learn 'knowledge where' the micro can assist in the learning and teaching of mathematics.
The role and influence of the universities further compounds the difficulties associated with the mathematics curriculum. Traditionally, the mathematics curriculum in Ireland has been developed by a 'top-down' process where the primary stage prepares for secondary, which in turn prepares for third level education. A major aim of the reform measures of the 1960's was to strengthen the link between 'school' and 'higher' mathematics. Unfortunately, the area of interest of the third level sector has always been in the area of curriculum content rather than curriculum pedagogy. In recent years, it has utilized a controversial points system for gaining entrance to third level education. This system is operated by means of assigning different numbers of points to different levels of performance in the subjects presented from an applicant's Leaving Certificate results. The points system has exerted a directive influence on the range of curriculum subjects offered by post-primary schools. This is clearly evident in the refusal by universities to allow technical subjects to be recognized as entrance qualifications. On the other hand, mathematics is not only an acceptable subject for obtaining 'points' but a number of third level institutions have assigned an additional weighting to the subject. Moreover, ever since Leaving Certificate subjects were accepted for entry to tertiary education, third level institutions have a more determining influence than before in shaping the syllabi of subjects at post-primary level. This was graphically demonstrated in the case of mathematics by the role of three professors in determining the final format of some topics in the recently revised syllabi at Intermediate Certificate level (see Chapter 2).

Universities are able to maintain this awesome influence since they are, by and large, seen as the pinnacle of educational aspirations. The real tragedy is that universities cater only for the academic child. Consequently, thousands of students are innocent involved - up to eighty per cent of the school-going population. The entire emphasis in post-primary schools is to perpetuate a system geared towards an elite, with unfortunate consequences for the vast majority. It is the
latter group who feel the stigma of failure when they do not succeed in achieving a 'points' total that was never within their capabilities. Not only has the university points system ensured an exam-orientated mathematics curriculum along with determining actual content areas, but of much graver concern is that the mathematics curriculum for the non-academic pupils consists, in the main, of a watered down version of that offered to their academic counterparts. The high failure rate in secondary mathematics indicates that schools have become rather adept at making a large majority of the pupils very aware of their inadequacies.

It is, thus, fair to say that the examination system and the third-level sector have a lot to answer for. Both constraints constitute a serious impediment towards post-primary schools achieving a defensible set of mathematical aims, as espoused in the previous section. An additional factor is the perpetuation and legitimation of such structures by societal attitudes to, and expectations of, education. The academic side of education is seen by the teachers and parents alike as being that which should be aspired towards. The author, in the teaching situation, has experienced many parents who hold unrealistic expectations for their children. These, in turn, are communicated to their children who are often (together with teachers) under incredible pressure to achieve what is often patently beyond their capabilities. School management authorities, especially voluntary secondary schools, must be encouraged to gain confidence to begin a radical overhaul of the present grossly flawed system and to make a conscious decision to shift the emphasis from exam performance to overall ability and achievement. This plan of action should be such that pupils who do not have the interests or aptitudes suited to third level education should have available to them a mathematics curriculum drawn up and developed with a view to meeting their particular educational requirements. It is difficult to expect teachers or parents to do it on their own if school authorities do not assume leadership responsibilities.
In the past, attempts at improving the mathematics curriculum in order to cater for such pupils have tended to proceed with a strongly structuralist or functionalist frame of reference (see Chapter 2):

- Pass and Honours mathematics programmes
- the implementation of the Vocational Preparation and Training
- a three-tier syllabus at Intermediate Certificate level using a differentiation strategy based on content.

Such structural solutions help solve only structural problems. Real progress cannot be made until societal expectations to, and expectations of, education are altered. Such a development can help to facilitate the construction of a more meaningful mathematics curriculum for the majority of pupils, one which is perceived in terms other than 'success' and 'failure'.

3.4.3 New technology and the content of the school mathematics curriculum

The extent to which new technology will/should affect the content of the school mathematics curriculum at post-primary level is fast becoming an issue of major concern. The historical perspective of the previous chapter indicated a lack of searching analysis on the role of the new technology in the teaching and learning of mathematical content. It was noted that calculators, for example, are not yet permitted at junior cycle and the attempt to introduce microcomputers in a mathematical context approximated to a 'piecemeal' approach. In short, the situation in this country is very unsatisfactory. Without becoming too daring, the debate on the role of the new technology vis-a-vis mathematical content needs immediate analysis and strategies for implementation at the classroom level. This brief is confined to a more detailed look at the place of the calculator and the microcomputer.
With regard to the calculator, the potentiality of the tool in helping children improve their performance at arithmetic has not been exploited. Likewise, its possible use for the teaching of other mathematical ideas and concepts has received insufficient attention. Learning how to use a calculator sensibly must now become an integral part of learning arithmetic. As a teaching aid, they help students acquire the important skills of estimating and approximating. Prudent use of the calculator can enable students to generate number patterns, explore number properties and test hypotheses. There is more time available for genuine mathematical content through a reduction of time spent on tedious calculations. The teaching of statistics is enhanced by the ability of the calculator to deal so quickly with numerical data. In senior cycle mathematics, such topics as geometrical progressions, exponentials, infinite series and factorials can benefit from widespread use of calculators. The author’s experience of students using calculators in the senior cycle mathematics programme is a pleasing one. It has helped promote students’ problem-solving capabilities and increased motivation and interest among weaker students. Positive attitudes to calculating and mathematics, as a result, have been fostered. Fortunately, some educational publishers have not taken the same path of inertia carved out by the Department of Education. A number of recently published mathematics textbooks for the new Intermediate Certificate syllabus contain a chapter on how best to use the calculator as a teaching aid.

Thus calculators have an essential role to play in the mathematics curriculum of the future. The implications for teacher educators are clear: mathematics teachers need to be trained to integrate calculators successfully into their teaching strategies, thus enabling students to acquire a better arithmetical understanding. It is especially important to ensure that the increased accessibility of microcomputers does not prevent attention being devoted to exploiting the potentiality of calculators for an improved mathematics pedagogy.
How will/should microcomputers influence the mathematics curriculum in post-primary schools? It has already been stated that computing will not replace mathematics nor will the ultimate aims of school mathematics be drastically changed; instead there are likely to be changes of curricular emphases. With this in mind, there is a need to rethink and reappraise the present mathematics curriculum and highlight probable implications. These new curricular emphases have been summarized by the Ware Reports [75] (pp. 7-8) under the heading "major effects of the microcomputer on mathematics teaching". It is appropriate to look in more detail at a number of these which impinge upon the teaching, learning and content of the mathematics curriculum. Firstly, there is an increased emphasis on making the dynamic algorithmic approach more pervasive and within this there is a place for programming in mathematics. Secondly, programming and software packages should allow for "more mathematical concepts to be assimilated at a lower level of abstraction by a wider range of ages and abilities" [75]. Thus computers can enhance understanding. Thirdly, the learning process in mathematics can now become less structured and more pupil-centred. Fourthly, the ability of the microcomputer to manipulate symbols has resulted in the availability of software to carry out all the calculus techniques taught at senior cycle. Likewise, due to the discrete nature of the microcomputer, interest in discrete mathematics - Boolean algebra, graph theory etc. has increased enormously in recent years. Consequently, the traditional emphasis given to the calculus at secondary level has been subjected to scrutiny. Finally, new opportunities for teaching and learning mathematics are opened up through the use of the computer. Students can use computer software as a tutorial aid to help facilitate the learning and understanding of such topics as geometric transformations, statistics and probability, where the gains from being able to simulate are enormous. Turtle and 'flatland' graphics offer new insights for the study of geometry. The mathematics teacher can use the computer as a teaching aid to perform calculations and to encourage experimentation and investigation. The availability
of software to carry out a wide range of mathematical tasks can help promote the development of these key processes. This emphasis on mathematical processes is in tune with what mathematics educators have been advocating (see section 3.3.2). Corroborative evidence is supplied by an ICMI study [94] which pointed out that exploration and discovery are important components of the educational process of mathematics which are greatly facilitated through the use of computer technology. Such experimental work with the computer can utilize the inductive paradigm - compute, conjecture, prove - and this can be usefully applied in many different situations.

This synopsis indicates the tremendous potential of the microcomputer for influencing the mathematics curriculum and teaching in the near future. However, despite the benefits which can accrue, it would be unwise to ignore the existence of a number of obstacles in the Irish context. The previous chapter drew attention to the absence of a national initiative for information technology in secondary schools. This vacuum has led Moynihan et al [77] to identify a number of priority areas which have been seriously neglected in the Irish scene:

- teacher education
- courseware development
- provision of support structures
- hardware requirements.

The authors proposed the establishment of a new statutory authority - an Educational Technology Council - to help cope effectively with the challenge that lies ahead. Such an authority would co-ordinate the teacher training effort together with the development of courseware including quality control and evaluation. It would specify hardware for schools and establish a network of resource centres on a regional basis [77]. The present analysis prompts the author to suggest an addendum to the proposed new structure with special reference to mathematics. There is an immediate need to initiate an inquiry into the impact of computers and technology on the mathematics curriculum and its teaching and to make recommendations as to changes which may be necessary.
Such an inquiry will need to address the question of "how much time can be spared to explore the many possibilities opened up by both the calculator and the microcomputer in an already overcrowded mathematics syllabus?". It will need to consider to what extent will the use of computers for exploratory and experimental work prove difficult by disturbing the normal teacher-student relationship. The preparation of mathematics teachers to work in this new mode will require full discussion as will the search to select suitable tasks or situations for students to explore. Pilot studies will be required to help mathematics teachers to recognize, reinforce and consolidate what the students have learned. Thus, the inquiry will need to become aware that the problem facing the mathematics curriculum designer and teacher is to plan in order to co-ordinate, reinforce and unite computer learning experiences and to embed them within a growing mathematical framework which students can appreciate and utilize. The resultant outcomes and action-plans could then be accommodated in the proposed new national plan as envisaged by Moynihan et al [77].

3.4.4 Towards a restructuring of the mathematics curriculum

As already indicated, the structural approach of the 1960 reform measures failed to be as closely attuned with the majority of students' learning patterns as had been hoped and claimed. How then is the learning of mathematics to be structured and how is the students' acquisition of such structures to be facilitated? Recent attempts to provide differentiated mathematics curricula at Intermediate Certificate level have been dominated by a 'content' view of mathematics. This view has been couched in a linear model which provides 'high-level' mathematics (Syllabus A) for the university bound at one end of the spectrum and offering it to middle (Syllabus B) and lower-ability (Syllabus C) in a diluted form, with the latter equating to 'low level' utilitarian mathematics. In the U.K., the Cockcroft Committee
[1] disapproved of such an approach but their 'bottom-up' approach can be subjected to similar arguments. It essentially accepts the same linear model, one in which their point of initiation is the 'low-level' foundation list. To this list is added topics in the belief that higher ability students will attain 'high-level' mathematics. It is not altogether clear that this linear model is the one which best accommodates the goal of compulsory "mathematics for all". In Ireland, the model has failed to take cognizance of the remarkable developments in the applications of mathematics which the information revolution has brought. The previous sub-section has already indicated how the microcomputer may well offer a rich source for experiments and developments with new content which could be 'nested' within a new model.

In search for alternatives, one must ensure that the underlying framework of the new model not only facilitates students' learning but in addition helps to illuminate the mathematical aims espoused earlier in this chapter. It must address the key question "what is it that we want students to learn in mathematics?". This in turn will need to take into account a judicious balance between 'process' and 'content' as hinted at earlier. Any serviceable alternative ought to provide also for an understanding of mathematical knowledge in its various forms and furthermore an additional emphasis on how to 'manage' this mathematical knowledge successfully.

An alternative to the present compartmentalised curriculum is a restructured mathematics curriculum on the basis of the applications of mathematics. The desire to relate mathematics to reality is not novel but in Ireland the determining influence of examinations and universities has contributed to a situation where the links between mathematics and reality have become neglected and distorted. The challenge of incorporating 'applications' into the mathematics curriculum is a complex problem as 'applications' can serve a variety of purposes.
Firstly, examples from 'reality' can be used in the service of mathematics teaching. Such links with the outside world are, on their own, unlikely to motivate a student to study mathematics. Moreover, the student may not be able to identify with the 'reality' link provided. Secondly, a different example arises when mathematics is used to solve problems as opposed to reality providing them. Earlier in the chapter, it was stated that students do not experience mathematics as an activity of solving problems, - questions in the public examination papers in mathematics tend to be overly concerned with problem-solving according to fixed rules and techniques. Two suggestions are offered to help remedy the present situation. Firstly, as various mathematical topics are taught, students ought to be given opportunities to solve problems that demonstrate some of the applications in other subjects and situations. Student motivation is increased but this would also result in increased demands being placed on mathematics teachers' knowledge and understanding of the uses of mathematics in reality if the contexts are to be meaningful. Secondly, inter-disciplinary project work could be encouraged to help promote 'applications'. However, the barriers confronting the latter alternative are enormous. It would require a major reorientation of the perspectives, skills and understandings of many mathematics teachers. It could not, for example, be easily accommodated in the present rigid Irish examination system. However, such project work does provide valuable opportunities for learning about mathematical modelling and this aspect merits particular consideration.

These considerations indicate that merely providing examples of applications for study in mathematics classes is not enough. A more fundamental analysis is needed, one which deliberates on the pedagogical purpose and justification of the various types of applications together with the specification of serviceable strategies for the innovation to actually reach classrooms in a worthwhile form.
Certainly, a change is needed from the present mathematics curriculum which tends to describe learning and prescribe teaching and in the process deny the experience of success to many students. Again, returning to the complex problem of differentiation, an alternative to the present ‘content’ orientated approach in Ireland would be the construction of a modular mathematics curriculum, offering a “core plus options” to all students. The core could be taught at different depths and a variety of teaching strategies could also be employed. Some options, for example, could incorporate the use of individualized material (the advent of the microcomputer in the classroom greatly extends the range of possibilities for such individualized work). In the process, mathematics can contribute to the more general educational goal - that of helping students to learn how to learn. It is readily acknowledged that such a curriculum is harder to construct than the traditional ‘top-down’ variety. Care would also need to be taken to ensure that the modular curriculum is not mathematically unbalanced.

The points and suggestions that the author has raised above illustrate the range of questions and options which must be answered and addressed before planning a new mathematics curriculum embracing both content and process. Clearly, it is not disadvantageous to engage in a healthy questioning of the privileged position which the traditional linear model has enjoyed with regard to secondary school mathematics.

As a practitioner, the author in recent years has experienced increased concern from parents on measurable achievement by students. Staff meetings of late have reinforced this perception of accountability as falling rolls increase competition for student numbers. There is a danger that such pressures as the fear of being held accountable for student failure may cause mathematics teachers to ‘close up’ and be unadventurous. There is also a risk that a preoccupation with accountability pressures will inhibit serious consideration of new educational ideas, including the search for alternatives to the present compartmentalised mathematics curriculum such as those outlined above.
It is essential therefore to examine more closely this increasing trend towards accountability and its consequences for mathematics teachers.

3.5 Accountability, appraisal and the mathematics teacher

3.5.1 Spotlight on accountability and appraisal

The author is acutely aware of an intensification of interest in teachers' work and a shift towards greater public scrutiny of this work since he began these researches in 1983/84 [83], [95]. Presently, teachers in Ireland are experiencing an age of unprecedented 'teacher bashing' by politicians, journalists and others. Mathematics teachers have not escaped the barrage. A case in point is the recent campaign enjoyed by the media over the falling standards in mathematics due to the unsuccessful reforms of the 1960's as the following headlines indicate [96], [97]:

"2 + 2 = 5. Snookered by the new maths - a generation of students without the basic 1,2,3!"

"After 25 years, 'New Maths' add up to failure at sums."

Moreover, the present Minister of Education has stated that accountability should be a feature of any change in education [98]:

No curriculum development would be worthwhile unless there was appropriate professional development for teachers and an adequate assessment/accountability system built in.

The Chairman of the new National Council for Curriculum and Assessment, Dr. Walsh, has condemned the permanence of jobs in the education sector, asserting that it served only to nurture incompetence [99]:

There is no reason why a fixed term contract system renewable on the basis of performance should not be introduced into the educational sector. (The author's italics)
Societal pressures in general are creating an expectation that the accountability of schools to the public should be more visible and more closely defined. These pressures are related to the growing trend towards consumerism in Ireland. The public, who are financing the education service, are becoming more conscious of its right to know how their money is being spent. With 'value for money' being increasingly promoted in other areas of life, the wish of the public to know more about how the sizable education budget is being spent is understandable. The previous chapter drew attention to the considerable growth of "parent power" in recent years. A recent letter (see Appendix B) by a concerned parent to an education journal bemoaning the fact that her son's mathematics teacher is being "monitored by no one" is further testimony to the current unease and unhappiness underlining the relationship between the public and secondary schooling. An additional source of pressure is the agonizing one of educational standards. In the absence of any convincing evidence to the contrary, the belief that there is something wrong with the standard of mathematics is growing in credibility. Recent cutbacks in education, leading to contraction within the teaching profession, have also increased vigilance with regard to educational resources.

In such a climate of questioning and public scrutiny, it is understandable that mathematics teachers may resort to an increased use of "exposition, examples and exercises" together with more drill in an attempt to cope with the new pressures and to allay the fear of being held accountable for student failure. Against this, mathematics teachers are faced with expectations from students, parents and others to make use of the new technology without the necessary support services. This latter pressure is not easily incorporated into the traditional teaching patterns outlined above.
Thus, mathematics teachers are faced with the integration of both stability (preservation and transmission of traditional values) and change amidst growing calls to evaluate their performance in the classroom. Accountability pressures have therefore been instrumental in bringing teacher appraisal to the forefront of educational debate. Is the current system of accountability in Irish secondary schools in a position to respond to the challenge without allowing undue outside interference whilst at the same time safeguarding the legitimate rights of the public?

3.5.2 The current system of accountability/appraisal

It is possible to identify two types of accountability in the post-primary system of education - formal and informal. The formal relates to statutory, legal or direct accountability where participants have to formally report to an individual or organization. Such accountability normally implies sanctions for those who violate norms. On the other hand, informal accountability resembles a form of answerability and professional responsibility to individuals, interest groups or organizations without the provision of having to report legally or formally to them. It is appropriate therefore, to examine accountability in the three post-primary sectors - voluntary (privately owned), VEC (publicly owned) and community/comprehensive schools (also publicly owned) - using the above classification.

(1) Informal accountability

All three sectors are answerable informally to parents, parent associations, students, teachers, employers, interest groups, the general public and government for the quality of education provided. The methods whereby this informal accountability is achieved are summarized in Table (11).
Table (11) Informal methods of accountability in post-primary schools

| A. Students         | Feedback to teachers on progress, term reports, students' views on how teacher and school is performing. |
| B. Parents         | Parent meetings, students' views, term reports, parent views. |
| C. Teachers         | Union meetings, teachers' views, staff meetings, discussions with principal, informal talks with colleagues. |
| D. Groups and others | Employers' views, media, reports, surveys, studies, manpower agencies' perceptions. |

(11) Formal accountability

All three sectors are required to apply the law of the land. VEC school principals are accountable to their Chief Executive Officer. The latter in turn, is publicly accountable to his VEC Committee and the media. Principals in voluntary secondary schools are accountable to their religious order, while principals in the community/comprehensive sector report to a Board of Management. All sectors have their 'quality of service' measured through public examinations. External examinations were introduced largely in an attempt to control teachers and teaching and this is still one of their major purposes. Teachers tend to view examinations as a 'mechanical contrivance' designed and imposed by others in which their job is to help students to 'overcome'. Finally, all sectors are formally accountable to the Department of Education. The effectiveness of this mechanism deserves further attention.

Accountability to the Department of Education is achieved through its inspectorate. In reality, the power of the inspectorate is very limited. Firstly, they operate on an individual subject basis in secondary schools and consequently
an in-school evaluation of the 'whole' school is conspicuous by its absence. Examination work and other administrative duties are tending to frustrate, over-burden and demoralize many inspectors. In the area of mathematics, the number of inspectors is very small (less than five) and in common with other inspectors, they possess few real powers with regard to taking action on ineffective teaching. There is a distinct absence of effective sanctions for all teachers who do not behave and perform to reasonable expectations. In blatant cases of incompetence, principals can earnestly request the particular teacher concerned to improve, but if he does not respond to offers of help and support, no other avenues exist at present for concerned parents to turn to.

In short, the inspectorial system is ineffective and, as a result, unable to achieve its monitoring role. Principals do not have any powers to control the behaviour and performance of their staff. Thus, mathematics teachers, who, along with their colleagues, constitute the most important input to the success of the post-primary education system, are effectively not accountable (in the formal sense) to anybody except themselves, through their own professional instincts. In the case of obvious incompetence on the part of teachers, the current position is unsatisfactory especially for worried parents (see Appendix B). The situation is exacerbated by the lack of systematic and regular in-school review and evaluation in Irish post-primary schools. Altogether, this lack of genuine external accountability constitutes a serious drawback in the Irish post-primary system of education. It has helped to contribute to the perpetuation of stagnation and lack of development within the system.

3.5.3 Accountability: a complex problem

The above analysis points toward accountability being a complex problem in the Irish post-primary education system. Yet, of all the pressures facing mathematics teachers, it is the one most likely to lead to most concern and apprehension.
Earlier in this chapter, it was argued that mathematics teachers must become more accountable for their actions as professionals. It was suggested that a professional code of practice, implemented through a Teachers’ Council (consisting of a majority of serving teachers) could provide a useful mechanism for increased accountability. This idea has received a favourable reaction from the largest post-primary teachers’ union [83]:

Discipline imposed by teachers on teachers will be accepted by teachers.

To date much has been said both privately and publicly about the professional conduct of teachers. A lot of criticisms levelled tend to be unhelpful and unproductive. Teachers must know what it is that is expected of them. Certainly what is not needed is a bureaucratic and hierarchical model of accountability with mechanistic and sterile features, one in which the role of the mathematics teacher is neglected. Such a ‘top-down’ scheme only encourages a negative and threatening perception of accountability. On the contrary, the succeeding chapters take an alternative view, one which firstly seeks to heighten mathematics teachers’ awareness of what appraisal could and should mean and secondly, to promote a national model of teacher appraisal which provides for a distinctive proactive and participative role for mathematics teachers. The primary purpose of such a system, it will be argued, is to improve practice in mathematics teaching. It is to be hoped that such a publicly recognized and approved system of appraisal will elicit voluntary co-operation, but one should not back away from measures which may have an increasingly coercive element if that is what reason demands. On the other hand, now is the time for mathematics teachers and the general teaching body to engage in productive dialogue to prevent the imposition of a monolithic system of accountability which would unduly hinder progress in mathematics education.

In general, the issue at stake is: “in what form will accountability/appraisal descend on mathematics teachers?”. This question on an appropriate form of accountability encompasses a wide variety of theoretical and practical issues
which serve to increase the complexity of the accountability issue in the Irish context. Such issues range through technical problems of appraisal, confidentiality, classroom observation, strategies for successful implementation at classroom level and the role of pupils and parents. The concept of individual teacher and school autonomy will be subjected to a new analysis. Any attempt to develop a professional code of conduct and practice necessarily involves a thorough review of what constitutes acceptable criteria for effective mathematics teaching. The concept of appraisal demands that mathematics educators must become aware of and understand these issues thoroughly. Ensuing chapters represent an attempt to explore these issues in detail.

This chapter has surveyed some key issues facing mathematics educators and the future of secondary school mathematics in the Irish context: the professional position of the mathematics teacher; the place and aims of mathematics in a technological society; the balance between content and process in the mathematics curriculum; the question of the character and extent of "compulsory mathematics for all"; the problem of drop-out and differentiated mathematics curricula and how mathematics can reflect and contribute to the Irish culture.

Mathematics educators charged with the future design and implementation of mathematics curricula must seek to come to grips with and thoroughly comprehend such issues. Future decision-making must depart from the present 'content' orientated approach which is concerned, in the main, with tinkering at a superficial level only. The issue of accountability, which has given rise to the concept of teacher appraisal, was highlighted as an issue of major concern. The remainder of this thesis is, for the most part, a contribution to the appraisal debate and the challenge it poses for all concerned with the improvement of educational provision. Firstly, however, attention is turned to an eclectic study in the author's school concerning pupils' attitudes to mathematics. Although pupils' attitudes have not been isolated as a major issue of concern per se, it has permeated
all of the issues in this chapter to varying degrees. This common thread was perceived by the author to be a major issue at classroom level to the extent that it was impinging on classroom practice to a significant degree. Conscious that pupil perspectives are rarely the basis from which one looks at issues of concern, the next chapter analyses, in case study form, students' attitudes to schools, schooling and the mathematics curriculum which they are exposed to. Lessons for mathematics educators are subsequently articulated.
CHAPTER 4

ATTITUDES OF PUPILS TO SCHOOL MATHEMATICS: A PILOT STUDY

4.1 Preliminary considerations

4.1.1 Rationale for case study

This study is concerned with the attitudes of junior and senior cycle pupils to mathematics together with their perceptions of schools and schooling practice in general. Why should attitudes command attention in the research arena? Most educators agree that attitudes play an important part in the learning process. Attitudes formed early on often persist throughout the pupil's school life. By and large, people regard mathematics as a hard subject. For many, it is associated with a strong sense of failure, and their memories of school mathematics are of tests and exams, of courses, of the fear of "getting it wrong". An over-emphasis on skills and techniques in the Irish context has led to a neglect of the "pleasure" and aesthetic side of mathematics (see Chapter 3). This imbalance does not help to promote pupil interest and positive attitudes to the subject. The following comment from a student who had completed the senior cycle typifies the unsavoury attitude towards mathematics [100]: (p.29)

While I was at school, many of my fellow students had a great fear of mathematics. This was, of course, no fault of our teacher. Personally, I feel that this subject, because of its importance, has been built up as a subject passed only by those who are considered "brainy". This concept of mathematics has been passed down from student to student. Since mathematics is so vitally important, I believe it is necessary to change students' attitudes to the subject, that it becomes a subject to be enjoyed, not endured. Maybe if students
could use calculators, they might have more confidence.

The historical perspective of Chapter 1 provides evidence to suggest that pupils' attitudes to mathematics continue to remain an issue of serious concern. It was indicated that the structural approach of the 1960's failed to take cognizance of student learning patterns. The complexity of some structures together with the excessive speed of their presentation (due to an over-crowded syllabus) did not provide a recipe for success with all pupils. Changes during the 1970's can be adequately described as 'modifications' to a mathematics curriculum which was designed essentially to serve only a small academic elite group of students. Finally, recent changes in the Intermediate Certificate mathematics syllabi attempted to provide a differentiation strategy based on content only. This attempt did not constitute a satisfactory response, reinforcing the prevailing linear model of "high-level" mathematics for the academic pupils at one end and "low-level" utilitarian mathematics for those pupils at the other end of the ability spectrum. This inadequate response to the complex problem of differentiation will continue to ensure that many students will flounder, understanding little and become increasingly disenchanted with mathematics and schooling. Moreover, those students will find it impossible to learn more mathematics should it prove necessary in the future. Students' attitudes to schools and schooling, and their conception of what comprises 'desirable' knowledge and understanding, are also affected by a technological environment. This means that entertainment and non-formal educational means—particularly television—are of a quality that cannot be matched by conventional school approaches.

Yet again, the historical evidence provided earlier points towards another inadequate response to this important development in which the potential of the microcomputer for enhancing pupils' understanding of mathematics (and in the
process promoting positive attitudes) has not been exploited.

Apart from the above scenario, which reflects an unsatisfactory climate for fostering positive pupil attitudes towards mathematics, it is possible to articulate two further reasons for engaging in an investigation of students' attitudes. Firstly, the thoughts and feelings of pupils towards the activities they engage in at school are an important feature of their learning. Secondly, a positive approach to any school subject constitutes an educational goal in itself and any information/data concerning any factors (for example, features of school life) which may influence such an approach are important in helping to contribute to worthwhile decision-making regarding pupil learning experiences. McManus [101], for example, found that pupils with positive attitudes perform significantly better in tests of mathematical achievement than do pupils with negative attitudes.

Matters are not helped by the scant number of studies on students' attitudes to mathematics. Much current research work is directed towards student learning and behaviour in relation to mathematical concepts and principles. There is still relatively little focus on students other than how they learn. Christiansen et al [102] did look at the classroom situation and how teachers' cognitive attitudes affect their teaching of mathematics. Teachers and educational researchers tend to view educational problems only through the eyes of teachers. Pupil (and parent) perspectives are seldom the point of departure in research work.

It is thus fair to say that insufficient attention has been given to students' attitudes to mathematics and to schooling in general, their expectations, perceptions and misapprehensions and their motivating drives.
At classroom level, the author has experienced at first-hand pupils’ frustrations and lack of success with conventional mathematical syllabi. This unsatisfactory position has, understandably, led to increased demands being placed on both the author and his students with increased calls for a more meaningful mathematics curriculum. What effect does this current climate have on pupils’ attitudes to mathematics and their perceptions of schools and schooling? Attitude is a complex variable affected by such related variables as achievement, teacher characteristics, content of courses and parents’ attitudes. How can the mathematics teacher, at classroom level, enhance his understanding and knowledge of pupils’ attitudes to mathematics and utilize the insights gained to implement serviceable action-plans? With this in mind, the author undertook a case study in his own school of attitudes of junior and senior cycle pupils to mathematics. A primary consideration was the evaluation and methodological approach employed.

4.1.2 The evaluation and methodological approach

The evaluation strategy deemed most appropriate to gain insights into students’ attitudes from their perspectives was the illuminative and qualitative approach. The three key features of this model - its holistic, inductive and naturalistic characteristics - have already been discussed at some length in the opening chapter. The author felt that the holistic approach facilitated an understanding of the situation (in this case attitudes) as a whole, which is critical for the interpretation of the data. Thus, for example, parents were identified as a relevant sub-group and their perspective serves to illuminate further the issue under consideration. Moreover, research [103] indicates the central role that parents play in student motivation, with fathers especially influencing the achievement level of the teenager. The naturalistic approach helped the author to avoid the imposition of a positivist and traditional experimentalist framework on the
research process, offering instead the opportunity to be flexible and responsive to changing circumstances. A number of research techniques were used in the collection of data: questionnaires, semi-structured interviews using audio-recordings, classroom observations, informal group discussions with pupils.

Thus, an eclectic approach adequately describes the variety of multiple research methods (triangulation) employed. In the case of junior cycle pupils, a heavy reliance was placed on qualitative interviewing. Following some preliminary pilot research, sub-scales and topics to be covered in discussion were specified to some extent in advance in outline form: the actual sequence of questions was decided in the course of the interview, depending on the context. In some cases, especially when pupils held unusual or interesting perceptions, additional questions emerged from the immediate context of the interview and these were pursued. In the course of fieldwork, it was felt that, at this rate, this flexible and fairly open-minded approach was appropriate in gaining information, insight and understanding into the complex area of pupils' attitudes. Patton [2] has summed up the strength of this approach in helping the evaluator to perceive the programme from the standpoint of the participants: (p.205)

This fundamental principle of qualitative interviewing is to provide a framework within which respondents can express their own understandings in their own terms.

Finally, the data which emerged from the above research approach was analyzed in accordance with the inductive approach pioneered by Glaser and Strauss [3]. This approach allows the dimensions of the analysis to emerge naturally in the course of the evaluation study.
4.1.3 The school setting: contextual features

The school is an all boys voluntary secondary school under private ownership by the Catholic church. It is situated in a growing urban town (population circa 15,000) in the North West. It has a present enrolment of 647 pupils, 73 of which are boarders operating on a five-day basis. The expansion of industrial enterprise in the region over the last ten years has led to a fifty per cent increase in pupil intake over the same period. The school offers a grammar school type education on Christian humanist lines, with less able pupils following, for the most part, a diluted version of the "high-level" academic curriculum. There is a five form intake annually, which is banded into higher and lower ability groupings. This form of streaming is maintained up through the school with setting taking over in the last two years. To date, entry has not been refused to any pupil but all pupils sit a common entrance examination. The examination consists of Mathematics, English and Irish which is the criterion used for grouping pupils into the top twenty per cent (two classes of equal ability) and the bottom sixty per cent (two classes of equal ability and a bottom stream of less able pupils).

There is a full time teaching staff of thirty five along with one full time secretary. The school structure resembles the pyramidal form, operating with a recognizable chain of command linked to relative status, having a vertical communication system and a leadership style approximating to Burns and Stalker's [104] (pp. 120 - 25) conception of a mechanistic institution. The concept of pastoral care is not formally recognized and individual form teachers attempt to carry out this important role according to their own discretion. There are no heads of department and in general, teachers tend to work most of their time as individuals, alone in their classrooms. The school is not involved in any curriculum innovation either at school or Department of Education level. Significantly,
the school does not have an explicit statement on aims, staff development, curriculum development or in-service education. These constitute serious deficiencies at a time when the information revolution and increased public scrutiny pose a new challenge to the quality of education provided by the school.

The present principal was appointed in 1982 and had previously been teaching for seventeen years in the school. He is also the manager in the sense that no formal structure exists whereby teachers and parents can become involved in the management of the school in a meaningful way.

4.2 Attitudes of junior cycle pupils

4.2.1 Collection of data and preliminary pilot work

This limited study of the attitudes of junior cycle pupils began in 1985 and concluded in 1986. Data was collected by means of individual tape-recorded interviews which were of a semi-structured nature. Altogether, fifteen pupils representing a mix of the ability spectrum were chosen for the study. All of the pupils were in their third year of the post-primary cycle and about to take their Intermediate Certificate examination. The framework for each interview was based on eight sub-scales (Appendix C). It was felt that pupils at the junior level would have encountered problems with the Likert-type Fennema-Sherman Mathematics Attitudes Scales [105], where a five-point scale ranging from "strongly disagree" to "strongly agree" is used. In arriving at the eight subscales, preliminary pilot work was achieved as follows:

1. Initially at least, it was felt that in order to discover patterns and reasons for them, the questionnaire framework must be comprehensive and relevant and should take quite a number of subscales. Having consulted a number of conventional mathematics questionnaires
relating to attitudes [106], [107] and from casual informal discussions with junior cycle pupils, the author arrived at the following twelve subscales for consideration:

1. attitude of pupils to school as a whole
2. pupil participation in the learning process
3. pupil confidence
4. anxiety and sex bias
5. satisfaction and success from mathematics
6. relation to other subjects
7. mathematics as an interesting subject
8. exam pressures
9. method of instruction
10. pupils' perceptions of teachers
11. parental attitudes
12. home environment/study habits.

The above subscales were then piloted in three local post-primary schools with the help of ten mathematics teachers and two third level lecturers with an interest in mathematics education. A short questionnaire (see Appendix D) was employed in this process in which the respondents were asked to rank-order the twelve subscales. Only two mathematics teachers failed to return the questionnaires. Upon subsequent analysis, the following seven subscales emerged as significant in the eyes of the respondents:

1. mathematics as an interesting subject
2. satisfaction and success from mathematics
3. attitude of pupils to school as a whole
4. home environment/study habits
5. pupil confidence
6. parental attitudes
7. relation to other subjects.

In arriving at the final format of the questionnaire for the semi-structured interviews (see Appendix C), the author included an additional "miscellaneous" subscale incorporating elements of those subscales which has been omitted from the original twelve.

4.2.2 Pupil interviews: limitations and precautionary measures

With regard to the validity of the results, it cannot be assumed that the items measured what they were supposed to have measured even though most of the subscales on the semi-structured interview sheet were designed to produce
data for analysis. For example, in answering either Question 4(c) or Question 5(a) (Appendix C), some pupils may have wanted "to please" the author by answering in the affirmative. The reliability of the research is obviously limited by the small number of pupils interviewed (15) but both the length (approximately thirty minutes) and the mutual atmosphere of each interview represented an attempt to generate worthwhile insights and information. To help achieve this aim, the following precautionary measures were taken:

(a) at the beginning of the interview, each pupil was made aware of the nature and purpose of the encounter and reminded that the interview was not a test with "right" or "wrong" answers
(b) the right to "pass" on any question was reserved for each pupil
(c) attention was drawn to the importance of openness and honesty and pupils were encouraged to expand at will on any issue; to this end, they were assured that their views would be treated in strictest confidence and not made available to other teachers in the school
(d) at all times, pupil responses were acknowledged either verbally or by gestures
(e) the author avoided making value judgments on pupils' comments and refrained from confronting pupils on their contributions
(f) when the occasion demanded intervention strategies by the author in the course of an interview these were either of a cathartic, catalytic or supportive nature
(g) a conscious attempt was made by the author to listen carefully to students' views and when necessary, clarification was sought by means of "how" and "what" questions as opposed to defensive "why" type questions.

4.2.3 Analysis of results

From the comments made by pupils during the interviews, a number of recurring themes emerge. These are presented below under appropriate summary headings.

1. Mathematics as a useful and interesting subject
Those pupils (the majority) who perceived mathematics as having a utility value related its usefulness to future life and practical situations:

(1) Mathematics is useful to help find jobs and to solve problems at home.

(11) Mathematics is not useful except for bills and for measuring.

A number of pupils who did not perceive mathematics as a useful subject justified their response by emphasizing that much of the mathematics learnt in school is not useful for everyday life. Such views indicate that insufficient attention is paid to mentioning the importance of mathematics for the pupils' own lives apart from examination purposes. This was graphically demonstrated by one pupil's remark regarding the inability of his class to see the usefulness and purpose of geometry:

On one occasion the principal asked what could geometry be used for. No one could answer the question and we are the top class. Pupils learn mathematics without any idea of its real benefits.

The issue of mathematics as an interesting subject provoked some emotive responses. In almost all cases the feelings expressed were strong and negative in nature and directed in the main towards the dull content of the mathematics syllabus. The term 'boring' was the common adjective employed by pupils with one pupil quantifying his response by stating that "more than fifty per cent of the course is boring". A number of topics were heavily criticized, most notably much of the geometry (especially theorems), logarithms and equations involving more than one degree. Such comments give an indication of pupils' frustrations with the current syllabus in mathematics. If schools exist for no other reason except to serve pupils, then such views ought to be considered at some stage during syllabus construction and justification. Finally, the usefulness of mathematics appears to be more significant in influencing
participation in the subject than whether it is seen as easy/difficult or enjoyable/boring. As one pupil put it:

It’s boring, but it must be done, because it’s needed later in life and to get a job.

2. Pupil anxiety and confidence

A slight majority of pupils expressed a lack of confidence in handling mathematics problems. One particular pupil was emphatic in his response as he understood the implication of his position:

I have absolutely no confidence in solving mathematics problems. I don’t like difficult problems and it annoys me very much as mathematics is an essential subject.

In general, those pupils who lacked confidence related their plight to "very difficult" problems and to particular topics. One pupil felt that his confidence had diminished over the three years due to ‘theorems’, which he found very difficult. Although it would appear unlikely that one topic would be solely responsible for pupils’ general feelings towards mathematics, it might be the case that success or failure initially rooted in one topic could trigger a positive or negative chain reaction that might eventually influence the general attitude. Further research is needed to illuminate further this latter area of concern.

Confidence in solving mathematics problems does not necessarily imply confidence in asserting oneself in class when difficulties arise. One of the “more confident” pupils put it like this:

I feel confident in solving problems because I am good at maths. Yet, if I get stuck, I would not raise my hand because I would be afraid of the teacher and what she might say.

Thus, anxiety in mathematics class can be related to teacher behaviours and not confined solely to mathematics per se. Those pupils (four altogether) who ‘dreaded’
mathematics related their anxiety to a variety of factors: a particular topic, 'poor' teacher at primary school, a feeling of isolation and frustration during difficult problems and topics or from not having homework complete.

3. Enjoyment and satisfaction from mathematics

Virtually all pupils linked satisfaction to success in solving mathematics problems especially in examinations. Even this type of satisfaction was all too often a rarity for the majority of pupils interviewed. The comments made give an indication that the experience of success is denied to many students at junior cycle level.

Not one pupil mentioned the 'enjoyment' aspect of mathematics. The 'pleasure profit' distinction made in the previous chapter has relevance in the present discussion. It seems that the 'profit' aspect of mathematics in terms of career prospects and examination success is the primary motivating drive of many pupils who study mathematics. The 'pleasure' side of mathematics, according to pupils' views, is restricted to remembering a formula, grasping a technique or procedure, attaining a good mark or simply acquiring the teacher's favour. This is not to say that such 'success' is unjustifiable for it does provide a degree of 'pleasure' for those pupils who experience it, rather that the 'profit' aspect ought to be tied in with more direct mathematical ends. Students ought to learn, for example, that with mathematical knowledge and understanding they acquire desirable power which can be utilized in the solution of their own problems and in their own decision-making. A number of pupils articulated unsavoury consequences due to the current imbalance:

(1) In the top class success is very important, as there is rivalry in the class to be better than the other boys.

(11) The class is very competitive, always comparing results.
Such a climate does not help promote and foster collaboration, co-operation and problem-solving in groups.

For many pupils the utility value of mathematics overshadows the debate on the enjoyment/satisfaction issue:

The real enjoyment will come when I will do well hopefully in the Leaving Certificate Honours mathematics course. So I feel time spent now on maths is time well spent for older pupils tell me how important mathematics is.

4. Transfer of mathematical knowledge

Only three pupils from the top stream were able to perceive a link between Algebra and Geometry and Sets and Functions. One of the three remarked:

I feel that most topics in maths are connected in some way. I don’t see a connection between Algebra and Geometry but I do see a connection between Sets and Functions - in the domain and range of Functions you have sets of couples which are really sets of points.

The appropriateness of the 'structural' approach introduced in the 1960's for the middle and lower ability bands is seriously undermined as the common reply from all the pupils in these brackets was: "I see no connection between the various topics". It is thus fair to say that pupils are not achieving one of the objectives of the Intermediate mathematics programme [43]: (p.40) "that pupils will understand the logical structure of mathematics". The impression gained is that the structures are too complex and presented too fast for the majority of pupils.

A number of pupils referred to their difficulty in remembering techniques when their use was required in subsequent topics. It appears that pupils have pockets of knowledge which are specific to the time they "did in class". Mathematical knowledge is not generalized in these cases. Moreover, much of the mathematics learnt was not
perceived as having immediate application in the world outside school or to subjects like Geography or the Biology section of their Science course. This inability to transfer mathematical knowledge into usable forms, either in reality or across subject boundaries, only contributes to a sense of frustration and alienation and all that it represents for the pupils concerned (the majority) during their later years of schooling. In this connection, the 'comparmentisation' of knowledge is a contributory factor (see Chapter 3).

5. Pupil passivity

Insights were gained into the degree of pupil activity/passivity in mathematics classes as illustrated by the following comments:

(1) The teacher generally asks a question, she calls people up to it on the board. At the start of a topic, the teacher does all the work and we take down notes but then we tend to become more active.

(11) The teacher usually does most of the work at the board and always decides what topic is to be done next. There have been occasions when pupils asked the teacher a question and the teacher didn’t have the time to answer.

Although two pupils stated that their mathematics classes were 'generally active', upon further investigation it emerged that their perception of 'activity' in mathematics approximated more to 'note-taking' and to doing exercises than to genuine participation in the class. In general, the scenario is depicted by pupils sitting in their seats following an inactive and regular routine of "exposition, examples and exercises". Groupwork, for example, was not utilized by any teacher as a teaching strategy - indeed three pupils expressed strong negative feelings towards any suggestion of introducing groupwork on grounds that it could 'make you lazy and only the bright pupils would benefit'. One perceptive pupil showed insight when he stated that mathematics teachers are not to blame totally
for the lack of genuine activity and participation as the syllabus is too long and over-crowded.

It is of significance to note that on the question of whether pupils should be allowed increased consultation and participation in decision-making both in syllabus design and in mathematics class generally, the general response was in the affirmative:

(1) Yes, I would like greater say in what is done in mathematics for the Intermediate Certificate - topic-wise. I feel that if pupils aren't good at a topic, they shouldn't have to do it. Sets and Geometry should be omitted.

(11) I would like to have more say in course choice in mathematics for the Intermediate Certificate. Computers and calculators should be used to make maths more interesting.

Research [108] also suggests a positive correlation between student participation and improved attitude in terms of greater reported satisfaction and decreased hostility towards staff.

6. Features of school life

Pupils' perceptions give an indication of how certain features of school life can influence their attitude to school subjects and their relationship with teachers and schooling in general. Their comments help to shed light on what actually goes on in schools and suggest that mathematics educators should study afresh the relationship between human behaviour and the contexts characteristic of the school as an organization:

(1) I am reasonably happy in school but I don't have a choice no one wants to go to the vocational school. It is only in Lifeskills and History that you are asked to give your opinions. The weak students are never asked to express their views.

(11) You get no real choice of subjects. I would like more metalwork and woodwork and we
don't even have P.E. this year. In all, there is too much emphasis on 'books' in the school for my liking.

(P) Pupils don't really have a say in the school. The prefect system can't work as the principal and teachers pick their own leaders. The prefects are not going to cause trouble. All pupils should have a say and each class should have their own prefect.

(PR) This school hasn't changed in my three years. Too many teachers are too formal and some don't want to talk to you. Why can't we have a good Transition Year and Vocational Preparation Course like the other schools in the town?

(V) Often teachers do not recognize the kinds of problems we have. Some teachers are too strict with rules and uniform while others are too easy and you have a lot of bullying going on. One day the principal suspends you for not having a tie - another day he gives you one from the lost 'property' box. There are some poor teachers that I would not like to have for class.

These comments contain implications for the nature of leadership and authority in the school and for teaching performance. The perceptions also suggest that pupils are entitled to a more participative role in school decision-making where their views will not be ignored. As the pupil is the consumer, this ought to be a right and not a privilege. However, it is readily acknowledged that the participation of pupils and the development of interpersonal rather than impersonal relationships between teachers and pupils are problematic issues which merit further research. Bell [109] has referred to the 'ambiguous' role of the pupil, a 'given' rather than one of the determinants of school processes and outcomes. Pupil views also reveal that the school in general tends to concentrate on cognitive outputs to an inordinate extent and omit almost entirely the affective. In one sense such comments are not surprising considering that the school does not possess a statement of aims or involve itself in curriculum development, staff development or in-school
review. Moreover, neither the principal nor senior staff with management functions have received any formal training in education management. These organizational/management issues are not merely academic questions. Research by Rutter et al. [110] on school effectiveness clearly suggest that schools do make a difference to the development of their pupils and take seriously the view that organizational and managerial processes within the school are significant determinants of pupil outcomes.

7. Teachers, teaching and the pace of lessons.

For many items, there were comments about teachers, teaching and the pace of work:

(1) I feel I have disimproved over the three years at maths. The fact that the teacher changed has changed my performance.

(11) I got more satisfaction in achieving the solution to a problem in my first year as the teacher was much better at explaining things and every pupil got an equal amount of the teacher’s attention.

(111) I think the pace is too fast for most students and they miss out on the basics as the teacher is concerned about getting the course finished.

(1IV) What I like about our mathematics teacher is that he doesn’t force us to do the work, but will help pupils if asked to do so. Yes, the teacher affects the way you work in school. I like the way he gets us to tease out the answer.

Some of the above comments contain subjective or 'rough' appraisal of teachers' performance. Pupils, when asked, are usually willing to supply honest evidence regarding the quality of the teaching they receive. Although such perspectives are not difficult to elicit, the gladiatorial context in which they are often framed can lead to a heavy discounting of these perspectives. The problem appears to lie in the need to develop a suitable mechanism for teachers incorporating pupils' views and comments along
with suggestions for improvement. This theme is returned to later in the thesis.

8. Parental attitudes

It is evident from the comments that mathematics is held in very high esteem by parents who recognize that, in reality, mathematics is used as the primary screening device or 'filter' for entry to numerous professions. One pupil mentioned how this has affected his attitude to work in mathematics:

My parents, especially my mother, keep asking how I am progressing in maths. Yes, they would be more concerned if I got a poor mark in maths than say in geography which is not compulsory. I find I need to keep up a steady work rate in mathematics as a result.

Others mentioned the 'filter' use of mathematics directly together with the determining influence of the universities:

(1) Yes, parents think that maths is very important. They feel that if you’re good at maths then you must be good at everything else.

(11) Parents think that maths is an important subject for a combination of industry, career use and university purposes.

(111) They usually ask how I am progressing but don’t ask to see my books. They think maths is a very important subject for university purposes.

Although all pupils agreed that their parents would be more concerned over a poor performance in maths compared to other subjects, no mention was made of parents helping their sons directly by assisting with or checking their homework. The problem as one pupil saw it is that:

They don’t understand enough about maths to give us help.
4.3 Attitudes of senior cycle pupils and their parents.

4.3.1 Data collection

To investigate attitudes to mathematics at senior cycle, the author chose a Leaving Certificate mathematics class (twenty-eight pupils) who had just completed their first year of the two year senior cycle. Academically, the pupils were weak being the fifth and final stream class for mathematics. An indication of their ability level (as measured by examinations) can be gauged from the statistic that fourteen pupils of the twenty-eight (approximately 54%) failed (i.e. got less than 40%) the Pass Intermediate Examination in mathematics the previous year. Ten of those who passed got the minimum grade required. After informal discussions, the pupils expressed a desire to answer an open-ended questionnaire (see Appendix E) as opposed to semi-structured interviews. Some of the views which follow also include comments made by pupils during informal class discussions and recorded at the time by the author in diary form. Finally, in keeping with the holistic and illuminative nature of the evaluation, the attitudes of the pupils' parents were sought by means of a short questionnaire (see Appendix F) which received a fifty per cent response rate approximately.

4.3.2 Analysis of results

1. Pupil questionnaire

A. Attitude to mathematics at primary school

Only two pupils in the class stated a dislike for mathematics at primary school while the others mentioned such remarks as 'casual', 'lazy', 'basics only'. Two pupils commented as follows:
(1) It was easier because the teachers did not give exams often. It was too rushed but much more useful.

(11) I enjoyed maths at primary school where we did most of the work in groups. It was easier to pick up and less confusing. It was more realistic than the abstract stuff we do now.

The latter comment, apart from stressing the abstract nature of the Pass Leaving Certificate mathematics course, also draws attention to the lack of alignment between primary and post-primary school mathematics.

B. Present attitude to mathematics

It is evident from the comments that mathematics is a very emotive subject for many pupils and is often related to the abstract and difficult nature of much of the mathematics which they are required to learn:

(1) My attitude is not good because maths has no bearing on everyday life.

(11) Maths is harder now; some parts are not worth learning because they will be of no good for most jobs.

(111) I think the maths is totally out of date and I feel I will not need half the stuff except for exams.

(1V) I think the maths we do is an entire waste of time. I would like to learn maths that is useful. The present course is too spread out for a start.

Utility is mentioned frequently in comments being tied to such ends as job prospects or further education.

(1) I see maths as the most important subject after four years and I realize that it will be necessary to 'pass' mathematics for almost every sort of job.

(11) I find maths OK but I'm doing it only because I'll need it.

(111) My attitude has changed greatly: mathematics is now an essential subject for getting a job or furthering your education at third level.
One pupil referred to the motivating and enjoyment aspect that computers provided for him in mathematics:

I like mathematics in St. Eunan's after having done computers. It helped me understand trigonometry better and made the topic more enjoyable.

Sadly, the others did not mention at any stage that they enjoyed mathematics or found it to be an interesting subject.

C. Mathematics and career aspirations

Twenty four pupils indicated that they would require a 'pass' in their mathematics in order to get a job. However, after surveying their career aspirations from another item on the questionnaire, the author found (with the help of the careersteacher) that many pupils will not actually require a 'pass' in mathematics for their intended career. For the four pupils who said they do not need a 'pass', their attendance is sporadic, their motivation weak and their interest very limited in mathematics and to schooling in general. All four indicated that they were just attending class until they reached school leaving age.

D. Relevance of mathematics to the world of work

Virtually all of the students' comments on this item elicited strong and negative feelings:

(1) I think that mathematics won't be of any use at all for the world of work.

(11) Maths is not of any use except for a teaching job. It has not prepared me for the world of work.

(111) I think the arithmetic we do will be useful for the world of work but areas like theorems, cubic functions and graphs will be of no use.

(IV) I am very unhappy with the maths course. It prepares me in no way for going out into the world of work.
Despite such reservations, some pupils were quick to add that the utility purpose justifies their continued participation in mathematics:

Although the maths is not preparing us well for the world of work, I need to 'pass' it because any type of job needs maths.

In this respect, their motivating drives resemble those of their junior cycle counterparts.

There was widespread agreement on those parts of mathematics which pupils perceived as being useful/not useful for the future. Not surprisingly, the four rules of arithmetic - addition, subtraction, multiplication and division - received the most favourable rating. Statistics, fractions, percentages, rates and area were also seen as having a useful role. However, such topics and areas as theorems, functions and trigonometry were heavily discounted as having any real benefit in later life. One example typifies the type of response received:

I will find adding, subtraction, multiplication, division, fractions and volume and area useful when I leave school. Everything else will be of no use especially theorems.

One pupil thought that the teacher-pupil relationship compensated for the lack of relevance of much of the mathematics course:

A lot of the material we do in maths will be of no use but I like the discussions we have in class and the way you can talk one-to-one with the teacher if you have problems.

Two pupils, whose fathers are tradesmen, suggested that more attention be given to the skills of estimation and approximation.
E. Mathematics and arithmetic

Aware that practice at computational skills receive little attention due to an over-crowded mathematics syllabus, the author included six 'sums' for pupils to attempt. Some of the results conjure up an alarming picture. Thirteen pupils (46%) incorrectly added 2/3 and 3/5, the common reply 5/8! Thirteen pupils (46%) also failed to find the value of 240 divided by 1/2 with 120 being the general response. Finally, eighteen pupils (64%) were unable to write the fraction 1/9 correctly as a decimal, giving .9 as their answer. Only three pupils in the entire class answered all six arithmetical questions correctly. The mean correct number of 'sums' for the class was 4.2.

F. Features of school life

Informal group discussions with the class revealed a worrying degree of disenchantment with features of school life generally. Pupils frequently mentioned the unsuitability of the curriculum in general and in many cases resented the unrealistic behavioural demands which are placed upon them. Another feature of school life which caused considerable dissatisfaction was their lack of participation and consultation in school decision-making especially in relation to matters of uniform, hair style and in the choice of subjects. Many pupils referred to the shameful neglect of P.E. on the senior cycle programme. These views reflect the sentiments expressed earlier by pupils in the junior cycle.

2. Parent Questionnaire

Parent perspectives are presented below under appropriate headings.
A. Mathematics as an important subject

A variety of reasons were offered by parents as to why they believed mathematics to be a very important subject. Most related to the utility value of mathematics for career purposes, thus reinforcing the perceptions of junior cycle pupils as mentioned earlier:

(1) I think mathematics is an important subject as it is needed in every job.

(11) Mathematics can help in thinking any subject through. It is also important for any trade and apprenticeship and third level institution.

However, one parent who agreed that mathematics is needed for most jobs, nevertheless condoned the use of mathematics solely as a 'filter' mechanism. Another parent showed insight into the service role of mathematics:

I feel mathematics is important because of its importance to other subjects - Science, Physics and Building Construction.

B. Assisting pupil progress at home

While all parents agreed that their son required a 'pass' in the Leaving Certificate mathematics examination, they rarely helped their sons at mathematics because they did not understand the mathematics themselves:

(1) I rarely help my son at mathematics because it does not make sense to me.

(11) I would like to help him more at maths but I do not understand them.

These comments reflect the views of junior cycle pupils as mentioned earlier. To compensate for this inability to help their sons a number of parents suggested that more attention should be given to weaker students as "they get discouraged if they are left behind". In this respect, they draw attention to the absence of remedial education provision for senior cycle pupils. Some of the remedies offered are unsavoury and indicate the controlling part played by examinations in Irish post-primary schools:
(1) Progress in maths depends on pupils’ aptitudes and those who have difficulties should get special attention.

(11) Not enough help is given to weak pupils. Grinds should be more readily available and here a list of teachers who are prepared to give grinds in mathematics should be made available to pupils and parents.

These comments serve to emphasize the concern which parents show for their sons’ progress: they want jobs for them (even if this costs extra money in tuition fees). Thus, the need for employment is foremost in parents’ minds and from experience the author has found that they manifest this concern frequently at parent-teacher meetings. An impressionistic comment gained from parent responses is that they feel that pupils fail the system if they are doing badly and not vice-versa.

C. Desired changes in mathematics

No parent expressed major concern with the content of the present mathematics programme course per se. In one sense, this is not surprising since people hesitate to initiate fundamental change in something that is already highly regarded (as a suitable screening device for entry to various professions) in its present state. However the following comments give an indication of the improvements which parents desire:

(1) Visits to offices and industries where the subject can be seen in use in everyday workplace would make the subject more relevant.

(11) If maths were made more simple, the weak pupils would remain interested. Yes, a work experience programme should be introduced.

(111) Work experience which would require pupils to use maths would help and make the school routine more interesting.

It is of some significance to note that one parent suggested that a third syllabus for weaker students should
be introduced and implemented to "make life easier for everybody".

Finally, when parents were asked if they would like to be consulted on the new changes currently taking place in mathematics, only a minority disapproved of the idea. Although the majority favoured increased consultation in policy decision-making, the need for parent re-education was highlighted as one means of overcoming ignorance:

I agree that parents should play a bigger role in the new changes in education. After all, we are paying for the service. However, a lot of parents would have to go back to school to help their children.

4.4 Summary and outcomes from pilot study

This pilot study set out to investigate the attitudes of junior and senior cycle pupils to school mathematics. The main understandings which the study has generated are summarized below.

(1) Attitude is a complex variable related to such variables as teacher characteristics and behaviours, the content of the courses, parental attitudes, the method of instruction and the attitudes of pupils to school in general.

(II) The aesthetic and 'pleasure' aspect of mathematics is neglected at both junior and senior cycle. The 'profit' motive predominates in an over-crowded syllabus.

(III) In top stream classes, individualism, rivalry and competition is widespread at the expense of co-operation and collaboration.

(IV) In general, pupils are dissatisfied and expressed emotive feelings with the present mathematics courses from the point of view of no applications value to the world outside.

(V) Pupils equate the utility value of mathematics almost exclusively to its usefulness for employment purposes. Mathematics teachers need to spend more time talking about mathematics and to help students appreciate the power and role of mathematics in its applications at the level which pupils have reached.
(V1) Pupils are unable to transfer mathematical knowledge gained in one topic to other areas, or to other subjects or into usable forms in the world outside school, thus indicating the failure of the structural reforms of the 1960's.

(V11) For the most part, the amount of active participation by pupils in the learning of mathematics is very limited. 'Acquiescent' participation aptly describes the reality. Cognitive outputs are emphasized and the affective domain seriously neglected.

(V111) Valuable insights were gained into the dynamic and complex nature of schools and how school features influence pupil attitudes to schooling in general. Pupils are unhappy with the nature of leadership and authority in the school and to the low level of pupil participation in school decision-making. These findings support research which strongly suggest that organizational and managerial processes within the school are significant determinants of pupil outcomes.

(1X) Comments about teachers and teaching give an indication of the type of informal or 'rough' appraisal of teachers by pupils. A mechanism is needed to help teachers benefit from such feedback.

(X) Parents bemoan the lack of remedial provision in mathematics at senior cycle. They are aware of shortcomings in the present mathematics course at Leaving Certificate level and suggested useful improvements. To facilitate parent consultation at school level, parents suggested the need for a major programme of re-education. With the inclusion of a familiarization programme in mathematics this would also help them to assist their sons at mathematics at home.

While the study did achieve its end, it would be wrong to generalize about the results in view of the limitations of reliability and validity mentioned earlier. In spite of these limitations, this pilot study is considered useful in providing guidance for a similar study on a much wider scale. Research will have an impact on the practice of teaching if and only if it produces, or leads to the production of, appropriate 'techniques' which can be adopted in the classroom. The research findings of this pilot study are of interest mainly to other researchers and
to curriculum developers, educational administrators and ministries of education. It is the latter who must ensure that such findings become incorporated into 'tangibles'—syllabi, methods, materials etc. which can be adopted by practitioners. In this connection, the author uses some of the insights gained from this case study in the development of an appraisal system and techniques for mathematics teachers later in the thesis.

On the issue of 'tangible techniques' for mathematics teachers, it is the belief of the author that the illuminative evaluation used in this study has significant applicability for mathematics teachers at classroom level. Although not previously mentioned, the triangulation of research methods employed by the author can be conveniently labelled action research. The latter is a cyclical or spiral research process with a proactive orientation. At the teaching/learning nexus, it simply involves mathematics teachers studying their own teaching, identifying an interesting aspect, collecting evidence about it and then acting on the results. In the author's case, attitudes was the area chosen for scrutiny and evidence was collected by a variety of research methods. What actions were taken by the author on the outcomes which emerged from the pilot study?

(1) At school level, he approached the principal and sought a participative role for pupils in the election of their own prefects. This was granted. He requested that the school submit an alternative mathematics syllabus for the less able pupils at Leaving Certificate level. The latter was not conceded on the grounds that the validity of the new course would be diminished in the eyes of parents and employers and pupils.

(11) At classroom level the author has:
   (a) made a conscious attempt to treat pupils more as participants in the learning process rather than 'fodder'. He continues to encourage and foster an interpersonal but yet authoritative teacher-pupil relationship allowing pupils to express their views and give feedback to him on his teaching performance.
(b) In an attempt to make mathematics more applicable within mathematics lessons the author has taken time to increase his own knowledge and understanding of the uses of mathematics in the outside world.

(c) In collaboration with a colleague, he has initiated an investigation into how the microcomputer can enhance the understanding of various mathematical topics. One outcome of this has been the establishment of a software library involving exchanges with local schools.

These 'action' steps were in keeping with the action-research framework as described by Kemmis et al [111] which incorporated four elements in the model: (p.7)

1. Develop a **plan** of action to improve what is already happening in the classroom.
2. **Act** to implement the plan.
3. **Observe** the effects of action in the classroom.
4. **Reflect** on these effects to plan for the future.

In addition to the aforementioned 'actions' which were taken by the author, two further outcomes merit attention. Firstly, on a personal note, the action-research experience has allowed the author to obtain a different perspective and professional orientation towards his teaching. He obtained a great deal of satisfaction, both in terms of task accomplishment and in personal and professional terms. This is a particularly commendable feature of the research process in view of the paucity of opportunities for Irish post-primary teachers to extend their professionalism. It is fair to say that in conjunction with the implemented 'action' steps, the whole process of engaging in proactive action-research has enhanced his teaching effectiveness at classroom level. Secondly, within the past year, a number of teaching colleagues have displayed keen interest in the author's classroom orientated research. From repeated requests, this prompted the author to hold a seminar for interested staff members on the merits and limitations of action-research. Almost
one third of the school staff attended the one hour session after school hours. A lively debate ensued and the presentation was supplemented by a summary for all who attended (see Appendix G). Teachers who agreed to 'try out' the research strategy indicated a willingness to meet and share their experiences in the forthcoming school year.

4.5 The re-emergence of accountability and appraisal

The previous chapter concluded by drawing attention to the increasing demands being placed on teachers, most notably the increased trend towards accountability. It was pointed out that the latter has been a primary factor leading to the demand for the formal appraisal of teachers. One outcome of the pilot study on pupils' attitudes to mathematics referred to the informal appraisal of teachers by pupils. The need for a mechanism to help mathematics teachers use such feedback in a productive fashion was highlighted. In short, the pupil as consumer must have a role to play in any appraisal scheme. Likewise parent perspectives ought to have a contribution in the debate on teacher appraisal. In this connection, the pilot study indicated that parents are willing to become involved in policy-making on education issues.

Understandably, many Irish post-primary mathematics teachers may feel that they should not be held accountable to a system where the mathematics syllabus is centrally prescribed with universities having a determining role and where there is no provision for individual student needs or regional differences. Yet, Thorp [112] argues that notions of accountability infer that the teaching profession ought to be responsible to pupils and to society as a whole:

(p.425)

It is entirely appropriate that teachers are responsible - responsibility is owed to their clients and the community for the way in which they do their job.
In the U.K., the government is insisting on the formal and regular appraisal of the performance of all teachers and this requirement is being linked to salary negotiations. This pattern is likely to affect education policy in other countries especially Ireland. It is fair to say that formal discussion on appraisal is in its infancy in Ireland. The time to prepare for appraisal is now. The remainder of this thesis is a contribution to the debate on the aims, objectives and methods of appraisal with specific reference to post-primary mathematics teachers. To this end, it is appropriate firstly to engage in a comparative study of appraisal, for the purposes of learning from the experiences of the process in other countries. In so doing, the evidence presented and the insights gained help to promote informed decision-making on an issue fast emerging as one of crucial importance and concern for Irish post-primary teachers.
CHAPTER 5

A COMPARATIVE STUDY OF APPRAISAL
(A review of the literature)

5.1 Introduction

The introduction and operation of a teacher appraisal scheme requires care, skill and sensitivity if it is to produce benefits for all involved. Much can be gained from a comparative study of teacher appraisal. In the quest for appraisal optimization, the experiences of how other countries have coped (or are coping) with the onslaught of this contentious issue ought not to be ignored. This chapter seeks to explore these experiences and to arrive at serviceable insights for those whose task it is to introduce appraisal effectively at school and teacher level. In the Irish context, a sense of urgency surrounds this task as appraisal begins to command increasing attention in both public and educational debate.

5.2 Industry and Commerce : Experiences in appraisal schemes.

After examining research in the industrial, commercial and public service in the U.S.A. and the U.K., Stenning and Stenning [113] (p.83) concluded that in assessing job performance for teachers, the following lessons and observations ought to be considered:

1. Context, i.e. organizational resources at the disposal of the appraisee.
2. Criteria for assessment are problematic especially in the area of defining teacher competencies.
3. Teachers can benefit from such schemes from the point of view of positive job satisfaction, status as a ‘professional’, improved classroom performance, more varied and interesting work and better results for pupils.
4. Effectiveness of appraisal schemes can be enhanced by a joint problem solving approach rather than a superiante dictatorial system.
Graham et al [114] (p.88) note that many of the new schemes in commerce and industry "incorporate 'open reporting' and encourage participation by the appraisee".

There is a fundamental difficulty in attempting to achieve comparability between appraisal schemes in industry and commerce with those in education. In the U.K., the National Union of Teachers has objected to appraisal schemes in industry and commerce as useful models for teachers on the grounds that such schemes do not take cognizance of contextual differences and the reality of the work of the teacher in the classroom [115], [116]. Yet, research in the U.K. [114] indicates that the predominant model of school appraisal schemes is the industrial one centered on target setting and on the evaluation of the extent to which targets set on previous occasions have been reached. Nevertheless, information such as the above, supplied from appraisal models in industry and commerce, can help highlight practical problems with the implementation of appraisal schemes for educational administrators, headteachers and teachers.

5.3 Some observations on teacher appraisal schemes in the U.K., Australia and the U.S.A.

5.3.1 The U.K. experience.

In the U.K., the debate on teacher appraisal has been to the forefront of educational debate since the early 1980’s. However the Government, LEA’s and teacher unions all hold diverging opinions on both the purposes and methods of appraisal. In the White Paper, 'Better Schools' [117], the Government’s intention was made very clear: (Paragraph 180)

The regular and formal appraisal of all teachers is necessary if LEA’s are to have the reliable, comprehensive and up-to-date information necessary for the systematic and effective provision of professional support and
development and the deployment of staff to best advantage. (The author's emphasis)

The Graham Report [114], based on visits to 62 schools, perceives the main aim of appraisal schemes as being professional development and the improvement of performance. At that time, only a small number of appraisal schemes were well established. The report also indicated that, where appraisal was an established and accepted process, headteachers and appraisers were committed; teachers knew the purposes of the appraisal process and their professionalism was enhanced and schools portrayed an open and welcoming ethos in the school. The report [114] which analyzed successfully run appraisal schemes did offer useful guidelines for the initiation of appraisal schemes after a computer search of the literature between 1980 - 1985: (p.26)

* Appraisal schemes must have a clear purpose.
* The process must take into account the differing contexts in which teachers work.
* The process should be evolutionary.
* The process should start with self-appraisal.
* Classroom observation should be seen as central to the process of appraisal. This should be carried out by teacher’s own head of department or principal and training is essential for appraisers.
* The focus should be on performance rather than personality and observations should be followed by an interview where teachers could discuss their own performance and ways of improving it. (The author’s emphasis)

The report also stressed that teachers and appraisers need to see observation in a constructive way and poor teachers should be offered support and training. After studying merit pay schemes in a number of countries the report concluded that its introduction would lead to disagreement and be counter-productive [114].

Should appraisal schemes consider pupil achievement? All teachers are apprehensive about scrutiny of results. Dockerell [118] (p.12) in the Scottish context points out:

If we are to appraise teachers, we must appraise their ability to help pupils learn,
and not other irrelevant matters.

A project [119] at the Open University School of Education in the U.K. collected information about pioneer schemes for teacher appraisal and classified them according to their salient features. The authors, Turner and Clift, found that in the U.K. at the time of the study, appraisal schemes could be grouped under three main types [119]:

* Appraisal interview by senior management, where the main emphasis was on improving individual teachers’ performance and the interview used to set targets for the following year.
* Observation and interview by senior management — usually by the principal.
* Departmental review, particularly the role of the Head of Department.

Only a few schools were found to be experimenting with peer appraisal or ‘open’ type systems as opposed to the more normal hierarchical model. Just over half of the schemes listed were of a voluntary nature and in many cases the principal was not appraised.

The shortcomings of using a summative approach only for appraisal purposes were highlighted at the Manchester (1987) conference [120] where the focus of concern was the appraisal of the advisory teacher service for mathematics. An alternative perspective was proposed which offered advisory mathematics teachers a more formative and interactive appraisal process. This proposal was supported by empirical data [120]: (p.2)

Our assertion that this kind of evaluation is likely to be of more immediate use is supported by the feedback we received from advisory teachers nationally who indicated that evaluation of an ongoing and participatory nature was (or would have been) most appropriate.

A survey [121] of existing schemes in the South-West of England has also shown that schools see appraisal schemes clearly aimed at improving individual performance. The three most popular aims testify to this [121]:
* to promote staff development,
* to review performance, identifying strengths and weaknesses,
* to plan future career activities.

The authors concluded that appraisal in some shape will be likely to be a feature of most schools by the end of the decade, but that very few existing schemes included observation of teachers at work in the classroom.

In a HMI report published in June 1985 entitled: Quality in schools: Evaluation and Appraisal [122], 80 primary, middle and secondary schools were considered which operated some form of self-evaluation or teacher appraisal. Consistent with the studies discussed above, they found (p.48) a variety of methods being used and emphasized the importance of observing a teacher at work.

Simons [123] in advocating such a model at whole-school level firmly believes that the chief purpose for school-based evaluation must be educational and professional and she supports her case with six assumptions including:

* that better understanding of the organization and policies of the school could improve the opportunities and experiences provided in classrooms;
* that participation in a school self-study gives teachers the opportunity to develop their professional decision-making skills, enlarge their perspectives, and become better informed about the roles, responsibilities and problems of their colleagues.

Research of appraisal systems indicates an academic orientation with little reference to concrete situations. A lot of literature deals primarily with evaluation models [124], [125]. Fortunately however, there are now a number of case studies in the U.K. which describe existing schemes in various schools. These offer to those interested in the theory as well as the practice of appraisal a rich source of material which has a contribution to make to the practical implementation of appraisal schemes and especially the importance of the influence which school processes and other complex dynamic factors can have on the successful implementation of appraisal schemes. One such case study is
described by a primary school head, Ian Sandbrook, in Craig [126]. It is illuminating to read about the introduction and the beneficial outcomes of the scheme, not least the sizeable impact that it had on his own personal development. One noteworthy observation of the success of Sandbrook's appraisal is the seemingly crucial importance that his knowledge of management education played in the success of the scheme.

5.3.2 Appraisal and the Australian experience

In Australia, the context is very different and teacher appraisal has for some time been regarded as an integral part of the employment contract. However, developmental systems of appraisal are not the norm and instead the main purpose appears to be 'promotional eligibility' [114]. After a limited survey of the Australian experience, the Suffolk report concluded that [114]: (p.82)

Evaluation is, therefore, merely a control device for the management of promotion.

However, the work which W.J. Smyth of Deakin University in Australia has been involved in since 1980 appears to have much relevance and potential for mathematics teachers who are faced with appraisal as an issue. Smyth's work, based on considerable experience, conceptualizes appraisal as being an empowering process of classroom-based professional development, not one which attempts to get at teachers by exposing their weaknesses in a quality control sense. Smyth refers to this process as clinical supervision which he defines as [127]: (p.183,185)

... a process in which teachers work together through systematic cycles of briefing, observation, analysis and discussion of data collected about teaching.

It is a way of thinking about, construing, challenging, and changing what we do as teachers.
It appears to allow teachers to become self-empowered and offers them opportunity to revalidate and possibly reshape their educational aims and objectives together with an examination of ways in which these can be best achieved. Smyth further advocates elsewhere [128] (p.12) that clinical supervision is a liberating process, where teachers help each other in a collaborative and collegial manner to gain control over their professional lives and future.

Also in Australia, the Teachers as Evaluators Project [129] (p.5) noted the potential of appraisal for school improvement suggesting that it be viewed as a co-operative venture and a school-initiated change process designed to yield information for in-school use.

5.3.3 Appraisal and the U.S.A. experience.

Like Australia, performance evaluation in the U.S.A. had, by 1983, been accepted as a legalized requirement in twenty-six states. The schemes do not appear to be as limited or as specific as was the case in Australia, with most citing 'improvement' as their main purpose [114]. Perhaps one contributory factor to the high number of states passing laws is attributable to the effect of the report - A Nation At Risk, compiled by the National Commission on Excellence in Education which was published in April, 1983. Recommendation D(2) on "Teaching" reads [130]:

Salaries for the teaching profession should be increased and should be professionally competitive, market-sensitive, and performance-based. Salary, promotion, tenure, and retention decisions should be tied to an effective evaluation system that includes peer review so that superior teachers can be rewarded, average ones encouraged, and poor ones either improved or terminated. (The author's emphasis)

Three years later, this message was reiterated when the Carnegie Forum on Education and the Economy furnished its report [131]. Whilst agreeing that legislation alone could not make teachers effective, the Task Force called for
teachers' salaries and career opportunities to be competitive with those in other professions. This was perceived to be a prerequisite in creating a teaching profession that would achieve much higher educational standards and in turn improve America's ability to compete in world markets. The Report also drew attention to the concept of "lead teacher" (approximating to Heads of Department in the U.K.) of proven ability and leadership, whose task it would be to assist in the redesign of schools and collaborate with colleagues in maintaining high standards of teaching and learning [131].

Much can be gained from a review of formative appraisal schemes in the U.S.A., such as that which operate in schools in New Jersey and described by Graham et al [114] (pp. 53 - 55). Features noteworthy of mention here are the attempts to arrive at agreed and relatively objective criteria for classroom observation; the avoidance of rating scales; a self-appraisal process followed by goal-setting which helps to highlight in-service training needs. Information on possible formats for classroom observation are also useful and contain much that might be applied in establishing a national appraisal system in this country. An understanding of the policy issues associated with implementing and maintaining appraisal schemes can also be gained from these formative systems of appraisal.

Finally, the notion of merit pay is topical in the U.S.A. with some schemes withholding annual increments following unsatisfactory reports. However, such schemes require thorough training of appraisers to ensure reliability and validity of observation instruments. Contextual differences present particular difficulties but this does not mean that attempts to reward good teachers in ways other than by financial methods should not be considered. Graham et al [114] (pp. 8-10) in this context recommend pilot studies with sabbatical leave and teacher fellowships and indeed their concept of "corporate excellence", where the whole school is rewarded when annual objectives are achieved, is an interesting one.
In contemplating the introduction of a national system of appraisal, teachers' concerns and reservations are an important consideration. These need to be examined empathically by educational administrators if appraisal is to avoid obstacles and problems at the implementation stage as mathematics teachers do have genuine fears and worries even those who are in broad agreement with appraisal in principle.

5.4 Appraisal and Teacher Concerns

The Suffolk report [114] (p.82) cites from its survey of the Australian experience that the process is normally accepted where the system is open and teacher involvement is maximized. Negative reactions however, were induced when assessment is external and/or when the criteria on which judgments are made are not known by the teachers. With regard to schemes operative in England and Wales, the report [114] (p.30) refers to the suspicions of teachers regarding the lack of agreed defensible criteria for observing work in the classroom.

An additional difficulty relates to the fact that the terms 'appraisal' and 'assessment' are often equated by teachers as being synonymous. This is not so and an attempt is now made to differentiate between them. Assessment relates more to quantitative or objective testing and implies the use of measurement and/or grading based on known criteria as in the selection of headmasters for schools. It is usually a 'top-down' or 'one-way' activity and in this respect benefits the 'system' as opposed to the individual. Appraisal, on the other hand, is a 'two-way' process benefiting the person being appraised (the appraisee) and ultimately these benefits will filter to 'system' level. Appraisal can thus be defined as the forming of qualitative judgments about an activity, a person or an organization. Unless teachers are aware of the possible inconsistency in the use of the two terms, 'appraisal' can too easily be perceived as threatening 'assessment' involving 'handed-down' judgments using rating
scales which incorporate criteria - criteria which were not agreed or decided upon by teachers beforehand.

Metcalfe [132], on a year's secondment in the U.K. talked to teachers in different schools about their reactions to appraisal. The amount of time needed was the most common complaint. The additional paperwork and form filling was mentioned along with the lack of privacy during interviews. A lack of clarity about the purposes of appraisal was expressed by teachers. Finally, externally imposed schemes were greeted with "suspicion" or even "open hostility" [132]: (p.94)

...... Particularly so when they felt under pressure to accept a scheme to which they felt that they had contributed little in terms of policy, planning and practice.

In the Irish context, Moran's [133] (p.8) study (100 teachers in five schools) revealed that the majority of teachers agree that some type of formal appraisal is necessary but not of a supervisory nature.

Research findings summarize the major concerns and fears which teachers have of appraisal [113], [114], [123], [132], [134]. These have been grouped under the following headings for ease and coherence.

The System: its development and implementation

* Lack of clarity about the purposes of appraisal and a mistrust for schemes which are used to facilitate dismissal, albeit intended overtly to improve performance.

* Teachers are opposed to the introduction of externally imposed schemes with little or no teacher involvement.

* Time for the appraisal process to be completed effectively.

* The confidentiality of the storage and use of the appraisal documents produced.

* The frequency of the appraisal process.

* Reliability of schemes especially consistency in and between appraisers as well as in common standards and
criteria for appraising classroom performance.

Training

* In particular, teachers are averse to appraisal by appraisers who are not thoroughly trained, who engage in inferential and subjective judgments and who lacked expertise in the teachers' subject area. Appraisers of this nature lack credibility and do little to facilitate trust and confidence.

* The relative lack of expertise needs to be acknowledged so that evaluative skills can be built on those that teachers possess. In general, the literature on techniques for appraisal has neglected to take account of the degree of skill expected of those in evaluating activities. This requires massive in-service training and can lead to concerns about the cost-effectiveness of appraisal schemes.

Resources and Follow Up Procedures

* Teachers are concerned about the necessary finance and resources needed to meet identified developmental requirements especially those of an in-service training nature. Here also, the needs of the teacher may conflict with the needs of the institution.

Although the above review is comprehensive, it does not explicitly refer to the significance of the psychological barriers and suspicions which teachers must overcome to facilitate the smooth introduction of appraisal. Firstly, any form of teacher appraisal could be perceived by teachers as a direct attack on their own professional autonomy. This fear is accentuated in the Irish context where teachers have, in the past, exercised this autonomy within their classrooms with no regular formal inspections from the Department of Education (see Chapter 3). Up to now, teachers' unions have jealously guarded this privilege and for many, the introduction of an appraisal process would be regraded as impinging on the right of teachers solely and entirely to make professional judgments about activities within the confines of the classroom. The problem is further exacerbated by the insularity of the Irish education system in general and the introverted outlook of many Irish post-primary teachers. Secondly, many teachers would express a natural suspicion about the ability of their colleagues
(senior or junior) to carry out an effective and credible appraisal. Reasons for the latter suspicion could hinge on the lack of training skills or the ability to implement such a process impartially due to past problems or past professional relationship difficulties. Finally, teachers will be naturally hesitant and reluctant to engage in an appraisal process which requires them to list those professional areas where they are either experiencing difficulties or need help and further training. Such an admission could be interpreted as jeopardizing their chances of promotion together with a general lowering of their esteem within the school. Teachers can also fear (and justifiably so) that ineffective appraisal could increase the level of cynicism within schools with a consequent reduction in teacher morale. These in-built resistances and apprehensions concerning appraisal are understandable and often reflect the tendency of teachers to be over-defensive. Moreover, these basic but fundamental suspicions can lead to a psychological reluctance on the part of teachers to accept appraisal as a major change in their work regime. In conclusion, it must be stated emphatically that in order to overcome natural suspicions and concerns, any appraisal process needs to be introduced into schools carefully and effectively.

Hostility and suspicion towards appraisal can be offset by an emphasis instead on the positive aspects of appraisal. Stokes [135] (p.72) argues that on most occasions, observations of teachers' work will reveal good professional practice and appraisal should thus be seen as a powerful vehicle for the encouragement and support of teachers. A similar view is propounded by Montgomery [136] (p.16) :

The essence of appraisal should be positive. Appraisal should be about "prizing" and "valuing" what is seen. This means determining the good features of teachers' performance, showing what they are good at. To do this, what they did must be mirrored and the meanings negotiated.
This section has emphasized the unlikely possibility of appraisal being successful if teachers are compelled to participate in superiate, mechanistic, externally-imposed or rating-scaled dominated appraisal. Despite the literature consistently advocating a shift away from this type of appraisal to a more developmental and formative model which is less prescriptive, it has already been noted that few schools are experimenting with 'open' or problem-solving type schemes. Fortunately one such developmental model has been pioneered by Rolph [137] and cited in Selmes [134], to which attention is now turned.

5.5 A non-hierarchical model for teacher appraisal and criteria for effective teaching.

In a recent article by Selmes [134], he describes his work with M.Ed. students and the different methods of appraisal which they examined. They explored the schemes from commerce and industry and they looked at methods of appraising student-teachers in the U.K. and U.S.A.. They looked at research methods involving classroom interaction and some of the formal systems operative in parts of Canada and the U.S.A. and concluded that [134] : (p.192)

In nearly all the cases it is the hierarchical nature of the systems to which most of the teachers object: indeed, it is the dangers of such systems which cause most concern.

He questions the practical use of 'appraisal interviews' for the majority of teachers insisting that [134] : (p.192)

Appraisal interviews are irrelevant to the task of appraising/evaluating teaching performance in a classroom situation. (The author's emphasis).

Selmes then goes on to devise an alternative framework and from this rationale arrives at new assumptions, which, for the practising mathematics teacher, seem more relevant and useful in the classroom context. The following assumptions underlie
his rationale for a non-hierarchical system of appraisal [134] : (P.192)

* The prime purpose is one of staff development;
* The evaluation should be carried out by the teacher's peers, fellow teachers and professionals;
* The evaluation should be based on criteria/qualities which have been jointly negotiated by the teachers involved;
* The system or techniques of evaluation should be one which is designed to provide data/information about the events of teaching so that the teachers can talk about their observations and discuss ways in which improvements (if necessary) can be made.

Selmes' rationale rejects the structural and rational view of social reality which assumes that what is significant in teaching can be measured and that, by adjusting the process, the desired 'optimal' effect can be achieved. Instead, he favours the interactionist perspective. This view emphasizes the importance that ought to be attached to teachers' perceptions of the teaching process and the validity of these judgments in an appraisal encounter.

Rolph's [137] evaluative technique endorses this procedure and Selmes [134] (pp. 193-195) describes how it can be readily adapted for a collegial model of peer appraisal in four functional stages. These stages along with the possibilities and limitations of this technique in the mathematical context for appraisal are discussed in detail in Chapter 7. Further evidence from the Manchester (1987) [138] conference lends support to Rolph's [137] evaluative technique where the process of agreeing the criteria jointly on a mutual basis was a significant element. Evidence supplied from an analysis of questionnaire responses indicated that a number of advisory teachers put great significance on criteria which would emerge from an agreed 'contract' for an involvement, to be negotiated between the advisory teacher and the school [138].

At this stage, it is useful to summarize the main understandings which this chapter has generated.
5.6 Important insights

This chapter has produced important and useful insights for those concerned with the introduction of teacher appraisal in schools. The comparative review drew attention to the need to avoid superiate and hierarchical type schemes. It also suggested that there appears to be a consensus on what constitutes acceptable principles for successful appraisal schemes. In this connection, it was indicated that the primary purpose of appraisal should be professional development and the improvement of teacher performance. Attention was focused on the need to perceive appraisal as an interactive and formative process which recognizes contextual differences. Teacher appraisal should start with self-appraisal and classroom observation is necessary. Training is vital for all involved in the appraisal process. Thus, the introduction of systematic appraisal will require a significant amount of scarce resources devoted to it in terms of time and money. In this connection, a major barrier to implementing teacher appraisal is the extent to which training needs or staff development needs can be met by both the Department of Education and schools. Teacher concerns and suspicions were articulated as areas of particular difficulty which need to be acknowledged if teacher rejection is to be avoided. Thus, the introduction of appraisal demands care and consideration if the process is to be effective. Careful planning and a diversity of strategies are required to overcome the obstacles encountered. To this end, the positive and empowering aspects of appraisal need to be highlighted, in particular the benefits that teachers, pupils and schools can acquire with a credible system of appraisal. These insights are utilized by the author in the development of a national system of appraisal in Chapter 7.

It was also noted that all appraisal is, inevitably, to some degree subjective. Rolph's [137] evaluative procedure, where the teachers agree the criteria for appraisal before the observation, was advocated as one means of avoiding this difficulty. Grounded on a different set of assumptions from
the hierarchical type schemes and derived from an interactionist perspective which emphasizes the person-centered culture, professionally appealing to the classroom context and more likely to be implemented by an individual mathematics teacher.

As noted above, a primary purpose of any teacher appraisal scheme ought to be the improvement of teachers' effectiveness. Both Selmes and Rolph are concerned with this aim and in this connection argue strenuously that the agreement of criteria beforehand by both appraiser and appraisee for effective teaching is crucial. Many views on teaching performance contain an implicit assumption that appraisers can recognize a good teacher when they see one. It is fair to say that credible appraisal must incorporate an awareness of what effective teaching involves. Yet, the debate on teacher appraisal has not given due attention to this requirement. The next chapter examines the concept of teacher effectiveness as it relates to mathematics teachers. The understandings gained are utilized, in conjunction with the outcomes of this chapter, in the development of a national system of appraisal and possible techniques for use by mathematics teachers.
CHAPTER 6

EFFECTIVE MATHEMATICS TEACHING: TOWARDS A MODEL FOR MATHEMATICS TEACHERS

6.1 Introduction

It is fair to say that if the improvement of teacher effectiveness is a primary purpose of teacher appraisal schemes (along with supporting professional development), then a detailed examination of the concept of teacher effectiveness is essential. Many would argue that they can recognize "good" or "effective" teachers. However, such judgments are often subjective, lacking a common set of guidelines, principles or criteria for appraisal. If improvement in teacher performance is the aim, then the appraisal process must relate to agreed criteria and avoid inferential and/or hearsay judgments. The heart of the problem lies in defining appropriate criteria for effective teaching - in this case, mathematics teaching. Fortunately, with the recent upsurge in appraisal, there is an increasing amount of material available, all attempting to define the effective teacher. This chapter draws together a representative sample of this material - material relevant to mathematics teaching. To this end, the discussion seeks to explore and analyze a number of critical characteristics and variables that make mathematics teaching effective and enhance the learning process. For example, "Do certain teacher attributes or characteristics play a part?", or "Do school processes within the school influence a teacher's effectiveness?", or "How can technology contribute?". The chapter culminates in the promulgation of a model for effective mathematics teaching. In this connection, an enabling strategy for implementation is suggested, one which takes cognizance of the importance of self-criticism on the part of mathematics teachers.
6.2 The concept of an effective mathematics teacher

The concept of an effective mathematics teacher is to say the least a problematic one and one which has gained considerable attention in a number of studies [1], [139]. Earlier chapters have already touched upon some of the internal and external constraints that impinge upon and affect the quality of mathematics teaching in secondary schools. The suggestion was made that mathematics suffers more than other subjects because of the linearity of the subject. This results in mathematics teachers tending to follow through topics in a logical approach which lacks breadth and depth and fails to make use of appropriate concrete experience. Mention was made also of the need to be aware of the academic bias inherent within the subject and its potential effect on the teaching of the subject. The professional position of the mathematics teacher (see Chapter 3) has resulted in insufficient time for reflection. This, combined with traditional routines and teacher isolation, has led to a vicious circle as shown in Figure 2.

In Chapter 3, attention was drawn to the limited autonomy of mathematics teachers in Ireland as a result of the centralized system in which they operate and this also affects teaching. Nowhere is this more evident than in the institutional manner in which the education system exerts its demands on the secondary mathematics teacher through the public examinations. There is evidence [9] to suggest that examinations have a limiting effect on teaching. Ravens’s research [48] showed that Irish teachers are to a rather alarming degree examination orientated. With growing importance being attached to good examination results, there is the possibility that matters might disimprove further. One consequence of this, according to Mulcahy [9] (p.161) is "examination teaching" resulting in mathematics and other subjects being conceived in "highly systematic, categorical and unimaginative terms". Thus, examinations are exercising a distorting effect on the teaching and learning of mathematics. It is a
Insufficient time for reflection and collaboration

Low morale

Traditional routine and relationships

Mathematics Teachers working in isolation

Figure 2: The depowering effect of reality on the mathematics teacher
constraint which does not entice the teacher to ask such
engaging questions as:

What am I doing in my classroom?
Why am I doing what am I doing?
What effects do my teaching
behaviours have on my pupils?

Despite what many would term a largely decentralized system of
education (at least up until the proposed reforms of Baker
(1988) come to fruition), similar evidence in Great Britain
compliments these findings. H.M.I. articulated these concerns
with respect to mathematics in a survey [140] which found
that: (p.117)

Very frequently teachers considered that
the need to cover examination syllabuses
and the need for their pupils to cope with
examination questions forced a restricted
approach to the ideas embodied in the
syllabus.

Examination success is thus a critical variable for
mathematics teachers and represents the teacher's need for
approval and thus must be considered an important affective
variable in the context of effective mathematics teaching. It
is a variable which is inextricably linked to the unhealthy
'top-down' influence which universities and higher education
institutions exert on secondary mathematics teaching (see
Chapter 3). However a recent discussion paper from the
Curriculum and Examinations Board (now the N.C.C.A.),
indicates that Irish teachers may in the future be required to
take a more participative role in the examining process.
Although highly appealing, is this a realistic aspiration in
the Irish context? It begs the question: "Do teachers want a
redefinition of their role and functions that will give them,
along with more freedom, an accompanying extra load of
responsibility, planning assessment and evaluation?". Thus,
the question of mathematics teachers being in a position to take
up this challenge and sustain it on an on-going basis needs
further investigation. There are training implications
looming for in-service education on a massive scale to bring
teacher skills up to a satisfactory level. Already, a number
of variables which impinge upon the effectiveness of
mathematics teaching have been identified. The next section attempts to explore and analyze other critical variables in detail.

6.3 Effective mathematics teaching and some critical characteristics.

6.3.1 Teacher characteristics

The need for approval, mentioned in the previous paragraph, was one of seven different variables which Begle [141] concerned himself with in considering attitudes of mathematics teachers and how these variables were related to pupil achievement. In his investigation of the characteristics of American mathematics teachers, he utilized data from the National Longitudinal Study of Mathematical Abilities (NLSMA) which represented some 100,000 pupils and their teachers over a period of five years. The seven variables under consideration were [141] :

(1) Theoretical orientation (whether teachers placed emphasis on teaching for understanding or rote learning).
(2) Concern for pupils.
(3) Involvement in teaching.
(4) Non-authoritarian orientation.
(5) Like versus dislike of mathematics.
(6) Creative versus rote learning of mathematics.
(7) Need for approval.

According to Begle [141] (p.46) each of the above variables was found to have a positive effect in general on pupil achievement in mathematics. The findings of NLSMA found that an emphasis on understanding as opposed to rote learning; a greater satisfaction and interest in teaching; a greater liking of the subject and a belief that mathematics is a creative process, all appear to relate to higher pupil achievement. However, personality attributes such as empathy, "warmth" and concern were found to be of less importance to
mathematical achievement than an emphasis on teaching for understanding and a stress on the creative aspect of the subject. Bennet [142] provides collaborative evidence when he found teaching style to be a more significant factor than a teacher’s personality. A non-authoritarian attitude on the part of the teacher was also correlated to higher achievement in mathematics, which would seem a necessary pre-condition towards a creative teaching approach to mathematics. It is no surprise to note the correlation between a teacher’s need for approval and higher mathematical achievement. The determining role which examinations play in the Irish post-primary sector has already been mentioned.

The NLSMA findings were contested by Begle himself and upon examination he suggested that none of the variables had a very strong correlation with pupil achievement and concluded therefore that they had no strong influence on teacher effectiveness. Begle pointed out that the effect of some variables differed depending on whether pupils studied mathematical courses of a conventional or modern nature. This led to a further analysis of the data and the main conclusion suggested that [141] (p.50) significant relationships between teacher variables and effectiveness scores were not frequent, appearing in no fewer that 30 percent of all possible cases. Affective variables were found to be more important than background variables and the former differed according to the age of the pupil. For example, at the age of 11 the creative aspect of mathematics was found to exert most influence on pupil achievement while at the 16 year old level the "need for approval" (on the teacher’s part) was the more important variable. The latter conclusion only adds to the difficulties of the teacher of mathematics in the Irish secondary sector due to the excessive emphasis on examination success inherent in the system. It further adds to the difficulty of defining exactly what constitutes effective mathematics teaching. The problematic aspect of the concept of the effective teacher is recognized by Begle [141] (p.37) who noted that the very concept of the effectiveness of a teacher may not be valid.
Trivett [143] (p.42) would also seem to accept the complexity of the teaching task, when, in an article entitled: "Which researchers help teachers do their jobs?", he refers to the importance of pupil exam success along with the constantly fluid state of the teaching environment which does not lend itself easily to prescriptive criteria:

It is not easy to sort out from all the possibilities exactly what for every moment guarantees any desired learning or behavioural effects.

To summarize, evidence is inconclusive as to what weighting should be attached to various variables, but it would appear that teachers’ perceptions of mathematics are a vital consideration in the complex classroom situation in which they work. These interact with and have an effect on other teacher attitude variables. Collectively they can be conceived as having either an empowering or depowering effect on the effective teaching of mathematics.

6.3.2 Quality of teachers

The quality of the mathematics teachers who are teaching the subject attracted the attention of Fletcher [144]. He suggested (p.204) that they must be "better in the sense of more fully informed, wiser and more adaptable human beings". Griffiths and Howson [145] (p.67) share the same concern and note that apart from technical competence, a good teacher will also have "dedication, unselfishness and a wish to make his pupils better."

Teaching competence and quality have been gaining increasing attention in Great Britain in recent years, and the 1980's have been an era of great change for the teaching profession. In recent White Papers - Teaching Quality [87] and Better Schools [117], a lot of criticism has been levelled at the "quality-control" arguments utilized. The Government in the U.K. has argued [87] (paragraph 29) that, because HMIs have found that nearly a quarter of primary school teachers and a
tenth of secondary school teachers showed "signs of insecurity in the subject being taught" there is a need for a closer match between qualification and teaching task if the quality of education is to be improved. However, there is little or no research evidence to show that a closer fit between qualification and teaching task would improve the "quality of education". The authors of the White Paper Teaching Quality [87] only consulted their own publications Ten Good Schools [146] and The New Teacher in School [147] and the picture which is conjured up is a confusing one. In Ten Good Schools [146] the authors note that: (pp.29-30)

The initial qualification of teachers, their length of experience or their years of service to the school are not necessarily prime factors in a school’s success.

However, in their research survey, The New Teacher in School [147] (paragraph 6.2) they found that "the personal qualities were in many cases the decisive factor in their effectiveness". Thus, the relationship between training, teacher effectiveness and school success is a confusing one to say the least of it. With regard to mathematics, the problem appears to be greater as there is a shortage of teachers in this subject in the U.K. [68] (no statistics are available on the extent of the problem in Ireland). Lacey [86] (p.68) has pointed out that tighter specification of subject specialism and level of qualification can increase shortages in 'vulnerable' subjects and disqualify suitably qualified social science students from teaching. One consequence of this might well be a decrease in flexibility and professional commitment in schools. The argument would appear to have an air of respectability as it stresses that the Government’s aim (England and Wales) is to improve professional standards but Lacey [86] (p.68) interprets this as a deflection of the real problem (one of resources and facilities) into one of control. This is presented to the teaching profession as a problem for it to alleviate. The crucial debate focuses on the word "quality" and the White Papers referred to above view teachers and teaching as products and does not give adequate attention
to teaching as a process and thus the concept of quality is limited and if it is allowed to become the norm, then the process of teaching and educating is liable to be downgraded and even ignored. If this belief persists, then it will not be difficult to foresee it becoming a self-fulfilling prophecy. Much more thought needs to be given to what constitutes quality in teachers, teaching and teacher education. That is not to say that qualifications and an adequate supply of suitably trained mathematics teachers are not important for effective mathematics teaching, rather the notion of "quality" needs reconsideration.

Furthermore, in Better Schools [117], the Secretary of State has required local education councils to assess the performance of their teachers on a regular basis. This development, along with the fact that reports on individual schools are being made by H.M.I. since 1983, is helping to ensure that the notion of quality control is already in operation. If these trends are followed in Ireland in the near future it will likewise affect the standing of the profession. Teachers of mathematics in Ireland do not control their own entry or stipulate their members' qualifications - thus there is a clear need for the development of a Teachers' Council for mathematics teachers. One of its first tasks might be to set out criteria for "good" or "effective" mathematics teaching in the context of classroom practice. This difficult task is attempted towards the end of the chapter. First of all, attention is focused on the alternative view of teaching - teaching as a process and its implications for effective mathematics teaching.

6.3.3 Process skills

Classroom teachers are in positions of enormous power and leadership, and the models they provide by their behaviours can influence school values and norms [110]. To be an effective teacher in the rapidly changing world of today requires us to rethink our model both of schooling and of
research into effectiveness. Has effective mathematics teaching been geared too much towards academic success, content and cognitive outputs to the detriment of the affective? For it appears that, because of the technological revolution, affective skills and effective skills (e.g. flexibility, maturity, coping skills, decision-making skills) are becoming increasingly more important in our society. Yet the discussion on effective teaching does not appear to take these fundamental changes into account. If teachers do not display and model these process skills and competencies, how are students expected to learn them and to cope with the demands of the complex world which teachers are trying to prepare them for? What are these process skills? Mayhew [148] defined them as:

(1) peer skills: the ability to build a network of contacts with one's equals
(11) leadership skills: the ability to motivate subordinates, and cope with the complications of authority, power and dependence
(111) conflict resolution skills: the ability to mediate conflict, handle disturbance, work under psychological stress
(IV) information processing skills: the ability to build networks, extract and validate information, to disseminate information effectively
(V) skills in unstructured decision-making: the ability to redefine problems and find solutions
(VI) resource allocation skills: the ability to decide on resource allocation, including the allocation of time
(VII) entrepreneurial skills: the ability to take sensible decisions and implement innovations
(VIII) skills of introspection: the ability to understand the position of manager and its impact on the organization.

The conflict resolution skills which Mayhew talks about would certainly involve a teacher's ability to handle effectively intrapersonal problems and worries or concerns. This would appear particularly important as there is evidence available which suggests that these areas cause teachers in general much concern. For example, Oldroyd [149] details a secondary school where a voluntary group of staff were encouraged to keep detailed diaries of their daily concerns, and to analyze them together before formulating alternative courses of
action. It emerged (p.116) that teachers were concerned largely about personal relationships and conflicts in the classroom and "whole school, community and national issues were little represented in the detailed reflections written at the end of each school day". Graham [114] (p.2) in attempting to analyze what "effect" teachers should be having on pupils also mentions these affective and effective skills. The author would concur with this evidence from his own experience of the teaching situation where similar concerns involving intrapersonal and interpersonal relationships surfaced. These examples give some indication of the complexity and dynamics inherent in the teaching process.

Kyriacou and Sutcliffe's [150] research on teacher stress also lends support to the notion that intrapersonal conflicts play a large part in teacher stress. Their research indicated that sources of stress with high mean ratings include pupils' poor attitudes to work and covering lessons for absent colleagues. Pupil misbehaviour and time pressures were also among the sources of stress which emerged, and the primary symptom of stress was defined by the reported frequency of feeling "very tense" [150]. The ability to handle effectively these situations of intrapersonal stress will undoubtedly affect the ability of a mathematics teacher to teach effectively. The development of intrapersonal skills deserves more attention in the pre-service and in-service training stages of a mathematics teacher's career.

This research points to the need for more individual guidance for mathematics teachers to help in improving their effectiveness. For some it may be the need for more technical knowledge of the subject, while for others it may well be one of the process skills that Mayhew referred to. Senior management in schools also has a role to play in the development and implementation of strategies to curb the increase of teacher stress.

If these skills are important and there is growing evidence to suggest that they are [151], [152] then they ought to be
included in the criteria for judging teacher effectiveness. Teachers should model these skills and understand that their pupils can learn from the modelling process as a result of their enormous positions of power and leadership. One limitation lies in the difficulty of measuring the efficacy of a teacher's work in the above process areas. Unlike the doctor, teachers cannot point to the "cure effected" nor like the lawyer to the "case won" as evidence of quality of work. Teachers do not deal with areas of deviation within the system such as illness or crime but with the whole person in all his capacities. The results of teachers' work are gradual rather than dramatic and very often unappreciated in an increasingly materialistic society, many of whose members tend to equate education with getting good examination grades which will lead eventually to a good job.

If fundamental changes in society demand that one takes this into account when deciding on criteria for effective teaching and that process skills as a result are useful for teachers to possess, it would be naive to neglect an analysis of the effect of the school as an institution and the importance of school processes that take place inside it. Teachers and classrooms do not exist in a vacuum. For example, the extent to which and the way in which the principal exercises leadership and authority will have serious implications for the way the staff and ultimately the pupils are able to exercise their leadership and authority. This in turn will affect the amount of real learning which goes on. Irrespective of the curriculum or the degree of social deprivation or the ability level of classes, these other complex dynamic factors will be of crucial importance. It is the inter-relationship between the principal, the individual, the patterns of organization of the school, the local environment and the global national scene which demands further understanding and further exploration, if that is possible.
6.3.4 School Processes

Part of the reason as to why these complex and dynamic factors did not attract a lot of attention can be attributed to the dominance (up until the late 1970’s) of the social systems theory. This theory depicted the school as an institution which interacts with its environment and the resultant model was of a linear input-output type which attempted to explain how things happen in the "real world". This model was appealing to educational administrators as it appeared rational, logical and orderly. However by the late 1970’s, it became clear that a distorted picture of what schools were actually trying to achieve had been produced and their purpose had been misunderstood. The theory did not contribute to our understanding of key areas of within-school life which might explain how a complex, dynamic institution functions, affecting teachers, pupils and learning along the way. What then does recent research into these areas of school life contribute to our understanding of effective schools, learning and teaching?

Further insight into school effectiveness is provided by a brief historical perspective spanning the past thirty years. There was a widespread belief in the 1960’s that schools could make a major contribution towards equality of educational opportunity for all pupils. However, this gave way to a series of attacks on the ability of schools to teach basic cognitive and social skills in the late sixties and into the seventies. The "Black Papers" in the U.K. (see for example Cox and Dyson [153]) typified this concern. Employers complained of standards falling in basic arithmetic, reading and writing. Essentially this challenge has leaned heavily on research [154] into school outcomes which suggests that (p.325) "schools bring little influence to bear upon a child’s achievement that is independent of his background and general social context". However this research (which had taken place mainly in the U.S.A. and the U.K.) had failed to pay attention to what actually goes on in schools and as a result an unreal and distorted picture has been depicted.
Fortunately, in the past fifteen years there are many studies which have emerged which suggest that schools do make a difference to the development of their pupils. These studies [110], [155], [156], have begun to show there are substantial differences in the effectiveness of different schools. They focus our attention on an examination of the inner workings of that system we call a school organization and the process factors operating within it. Some of the research findings are summarized below.

(1) British studies [110], [157] appear to suggest that variables such as pupil/teacher ratio, class size, quantity of resources spent per child, and quality/quantity of physical resources do not have major effects upon outcomes.

(11) A school’s informal “ethos” or culture or pattern that exists appears to be much more important in determining effectiveness than the formal organizational structure of the school. With regard to school ethos, Rutter et al [110] point out:

(a) a school’s “climate” or “ethos” is much more within the control of those who teach and are taught than is sometimes realized. We have a choice to coerce teachers/pupils or seek to enthuse them through a sense of involvement;
(b) the models provided by the teachers’ own conduct in school and by the behaviour of the other pupils contribute towards a school’s ethos;
(c) teacher expectations about children’s work and behaviour also affect a school’s climate.

(111) Skilful leadership in this matter of school climate is essential [158]. Firm leadership which combines high levels of pupil involvement in running the school with some degree of teacher participation along with a system of positive reinforcement appears to be associated with being an effective school [109].
There are strategies available for educational managers to plan and manage school climate and change purposefully in order to enhance their effectiveness [159].

Organizational Development theory and research in relation to schools have indicated some important research findings on effective school processes:

(a) staff who feel influential in school decision-making more often are involved in professional innovating
(b) staff who view their principal as influential are more likely to innovate
(c) staff who do not feel pressured are more likely to innovate
(d) most teachers want to have more decision-making power than they have
(e) schools in which the communication system is "flat" and promotes dissemination often contain teachers who innovate and share more than in schools with a hierarchical communication structure.

Purkey and Smith [160] on their review of research on school effectiveness argue the need for a better understanding of school processes together with "the nature and style of political and social relationships and the flow of information within the school". In making their case for a school culture model approach as an explanatory framework for illuminating the effectual nature of schools, they argue that "consensus among the staff of a school is more powerful than overt control, without ignoring the need for leadership".

Quite apart from the importance of the above school process factors, there is also a need to consider the now well-documented effect of "context" on teacher effectiveness. In a recent research paper, McKenna [161] advocates that cognizance ought to be taken of the effect of community, equipment and school objectives when considering the effectiveness of teachers.
In the development of teacher appraisal schemes, cognizance also needs to be taken of the manner in which management and colleagues provide varying degrees of support, opportunity and constraints for teachers. The importance of including this finding in appraisal schemes has been emphasized by a staff committee in Queen’s school in Hertfordshire [162].

Kyriacou and Sutcliffe’s [150] research on stress also identified (p.167) “poor school ethos” as one of the four primary sources of teacher stress. This reiterates the need to focus on and examine school processes and to consider the implication of the findings referred to in the above review.

What the above research suggests is that it would be entirely inappropriate to assume that the mathematics teacher and the effectiveness of his teaching are not unaffected by school processes within the school organization. As mentioned earlier, teaching (no matter what the quality) cannot be displayed in a vacuum. A context is needed and the teacher’s context is not just the classroom (although essentially effectiveness must emerge out of matters that do with teaching and pedagogy in the classroom) but additional process factors that contribute towards the effectiveness of any school. In other words, simply looking at one input variable viz. the mathematics teacher is to deny the significance of the nature of the school culture or organization or to deny the import that should be attached to the importance of pupils as an equally important input variable. Our vision can easily become distorted if it is not emphasized that it is the inter-relationship of the parts that affect pupils’ learning, both cognitive and affective. Thus the relationship between teaching effectiveness and school processes is an intricate one. Not only should we regard as problematic what and how we teach but it also seems appropriate to regard the school organization as essentially problematic as well. Getsels
[163] reminds us that while people who make up an institution may share common roles and expectations, they may implement them in highly individualistic ways. This phenomenon is not fully understood but additional knowledge would seem to be important for developing ideas and strategies in order to manage teaching and learning effectively. In fact, we still do not have a clear idea about which school process factors are associated with outcomes, nor do we have any real ideas as to how the process factors actually generate outputs. Can output quality affect process factors e.g. through teacher expectations? All these areas seem urgently in need of further investigation to improve our meagre understanding of within-school life.

6.4 Towards a model for effective mathematics teaching

6.4.1 Insights from current models

Any model for effective mathematics teaching must consider the outcomes of the preceding research and it is imperative that the process of teaching together with school process factors ought to have a bearing on what constitutes "quality" in mathematics teaching. Any model which is constructed must also take into account the specific pressures on mathematics teachers in the Irish context, especially those in relation to the constraints of examinations, time, stress and lack of professional support structures. Trivett [143] earlier reminded us of the need to avoid prescriptive criteria due to the fluid nature of the teaching environment. As a starting point, Bennet [142] provides a framework which mathematics teachers could use to discuss each other’s style of operation - a useful first step in the monitoring of teacher effectiveness. Bennet attempted to identify teaching styles by using models of what he calls "traditional" and "progressive" teaching. His research [142] identified eleven basic differentiating elements which are summarized below in Table (111) for both models.
Table (111) : Traditional and Progressive Teaching Styles

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Progressive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Separate subject matter</td>
<td>Integrated subject matter</td>
</tr>
<tr>
<td>2. Teacher as distributor of knowledge</td>
<td>Teacher as guide to educational experiences</td>
</tr>
<tr>
<td>3. Passive pupil role</td>
<td>Active pupil role</td>
</tr>
<tr>
<td>4. Pupils have no say in curriculum planning</td>
<td>Pupils participate in curriculum planning</td>
</tr>
<tr>
<td>5. Accent on practice, memory and rote</td>
<td>Learning predominantly by discovery techniques</td>
</tr>
<tr>
<td>6. External rewards used, e.g. grades (i.e.</td>
<td>External rewards and punishments not necessary</td>
</tr>
<tr>
<td>extrinsic motivation)</td>
<td>(i.e. intrinsic motivation used)</td>
</tr>
<tr>
<td>7. Concern with academic standards</td>
<td>Not too concerned with conventional academic</td>
</tr>
<tr>
<td></td>
<td>standards</td>
</tr>
<tr>
<td>8. Regular testing</td>
<td>Little testing</td>
</tr>
<tr>
<td>9. Accent on competition</td>
<td>Accent on co-operative group work</td>
</tr>
<tr>
<td>10. Teaching confined to classroom base</td>
<td>Teaching not confined to classroom base</td>
</tr>
<tr>
<td>11. Little emphasis on creative expression</td>
<td>Accent on creative expression</td>
</tr>
</tbody>
</table>

The Observational Research and Classroom Learning Evaluation Project - ORACLE (1975-80) [164] concerned itself mainly with a study of the relative effectiveness of different teaching approaches across the main subject areas of the primary school. Classroom observation was the primary research method used in this study of fifty-eight classrooms in nineteen primary schools. Mathematics teachers in secondary schools can still benefit by comparing and evaluating aspects of their own teaching to the "glassbox" model [164] provided by the study where the classroom is open to view and to look at teaching behaviours which they could adapt for their own individual use. It offers the possibility for mathematics teachers to obtain a window on their own teaching values and idiosyncrasies, and possibly changing what they do as teachers. In addition, both the research from the ORACLE study [164] and the work of Rutter et al [110] stress the case for teachers to become...
involved in their own self-criticism and reflection in relation to monitoring their teaching.

More specifically, with regard to mathematics, there are a number of models relating to effective mathematics teaching. Both models which will be examined accept that it is neither possible nor desirable to prescribe a definitive style of teaching for mathematics, reiterating once again the problematic concept of effective teaching.

According to Cockcroft [1] (p.71), the following are areas of teacher action which contribute towards effective mathematics teaching:

(a) exposition by the teacher
(b) discussion between teacher and pupils and between pupils themselves
(c) consolidation and practice of fundamental skills and routines
(d) problem-solving, including the application of mathematics to everyday situations
(e) investigational work
(f) practical work.

The Suffolk Education Department [165] after reviewing the literature arrived at the following characteristics, skills and behaviours which contribute to our knowledge of effective teaching: (p.22 – 23)

* effective teachers believe all pupils can learn, and such teachers take responsibility by organizing and assigning tasks and by other means to see that pupils do learn.
* effective teachers keep pupils “on task”, use unambiguous cues and provide evaluative feedback that is clear and instructive
* effective teachers use a variety of teaching methods ranging from “whole group” to “individualized” teaching; from didactic teaching to discovery approaches. Skill level, subject matter and the aims of the lesson determine the method chosen
* effective teachers use direct teaching when basic skill acquisition is the aim
* effective teachers are good managers of the teaching/learning process and of people. They use a variety of good management practices including setting a classroom “tone” or “climate” conducive to learning; preventing disciplinary problems through planning; eliminating disruptions and delays; monitoring pupil attention, i.e. keeping
all pupils involved and establishing clear rules and expectations for each lesson and for the class
* effective teachers develop a leadership style which is essentially democratic yet authoritative (not authoritarian); they view their role as helping the development of potential and assume that a sense of responsibility is inherent in every pupil.

The Schools Council [139] proposed a similar framework for mixed-ability teaching in mathematics which included: (p.21)

- quality in sound mathematical content and variety of tasks; suitability of tasks for pupils
- continuity and development of the mathematical learning of individual pupils and an awareness by the teacher of individual pupils' progress
- autonomy - the development of the pupil's ability to organize his own learning activities
- discussion - mathematical discussion between pupils and between teacher and pupil.

Essential as these are, insights gained from the Pilot Study in Chapter 4 together with the preceding discussion on the importance of teacher process skills and school process factors has prompted the author to add the following areas of concern to be included in the search for effective mathematics teaching:

* an increased awareness of the growing importance of process skills in managing the teaching and learning of pupils - the process skills which Mayhew [148] identified
* an increased awareness of school process factors
* teachers of mathematics ought to consider pupils as an important input variable and an integral part of the learning process and not as passive recipients of knowledge
* climate building with pupils with an emphasis on "contract" building especially in the first meeting with pupils
* planning and preparation skills which can help reduce discipline problems
* organization and management skills
* self-criticism by teachers themselves appears to be very useful as a first step in monitoring teaching effectiveness.

Cooper and Hall [166] describe the Schools Council's Programme Two and note the absence of a general consensus about what constitutes good teaching. They place particular emphasis on
certain personal qualities that appear to be associated with effectiveness including: (p.8)

- concern and caring for others
- emotional resilience, patience and tolerance to work well under pressure
- the ability and willingness to look ahead and make things happen rather than wait for things to happen
- the ability to self-evaluate, to stand back and be self-critical and to take responsibility for one's own personal and professional development
- recognize the strengths of others, not just their weaknesses
- the ability to acknowledge that, when negotiating goals, others may have different values and principles from your own
- drive and will to pursue goals
- courage to do what is right even though it be personally stressful and unpopular with others.

This research by the Schools Council is firmly placed in the context of classroom practice and the above teacher characteristics are the results of evidence provided by the experience of teacher-researchers at school and classroom level. These ought to find recognition in the search for an appropriate model of effective mathematics teaching.

6.4.2 Microcomputers and effective mathematics teaching

The discussion to date has not made reference to the role of the microcomputer in enhancing effective mathematics teaching. Yet, the availability of microcomputers must be perceived as having a fundamental role in assisting and improving the teaching of mathematics (see Chapter 3). Cockcroft [1] (Paragraph 374) speaks of "the very great implications" of the silicon chip for the teaching of mathematics and the fundamental need to consider "the extent to which the availability of calculators and microcomputers should change the content of what is taught or the relative stress which is placed on different topics within the mathematics syllabus".

Both the Ware Reports [75] and the Pendley Manor Report [76] refer to the role which the microcomputer can play in effective mathematics teaching, especially in relation to the model of effective mathematics teaching as outlined by
Cockcroft. These reports suggest that in particular, teaching in mathematics can be made more effective because:

(a) computer packages promote discussion; programming and investigational projects also highlight skills in communication, particularly if the project has to be written up
(b) investigations can be carried out by pupils themselves resulting in a much more heuristic and pupil-centered approach
(c) problem-solving skills can be enhanced
(d) demonstration software and programs can be utilized as a teaching aid for classroom use
(e) computers can reinforce the learning process in such topics as geometry, algebraic equations, statistics and calculus.

However, the Ware Reports [75] emphasize that the problems facing teachers in the classroom should not be underestimated:

Yet the problems facing teachers in the classroom should not be underestimated. Both in-service support and curricular recognition of the importance of computers in mathematics education is necessary if teachers are to be motivated to find the considerable time and energy necessary to gain familiarity, confidence and conviction.

Elsewhere, Cockcroft [1] (p.117) in the same vein states that "a significant proportion of the teaching of computer studies will be undertaken by mathematics teachers, who will in consequence have less time available to teach mathematics." Those mathematics teachers who are required to teach both computers and mathematics will experience increased pressure which is not conducive to effective mathematics teaching. There is also a consequence at 'system' level for effective mathematics teaching. If less time is available for mathematics teachers to teach mathematics, then it follows that the teaching of mathematics will be undertaken by others less qualified and less concerned. The effectiveness of mathematics teaching is thereby reduced and national standards jeopardized.

However, despite the fact that the task of mathematics teaching might become more time-consuming with the advent of microcomputers together with requiring skill development,
the potential benefits towards effective mathematics teaching appear great. On the issue of training, the Ware Report's [75] (p.60) argue that teachers of mathematics do not need to study the whole of computing. They need to be trained to cope with those parts of computing relevant to mathematics teaching, including mathematical aspects of programming (particularly in mathematical algorithms) and the use of appropriate software in the development of mathematical concepts [75]. The potential richness of the microcomputer in assisting the understanding, learning and teaching of mathematics is termed "Computer Enhanced Learning" (CEL) by Bajpai [167]. In this connection, an apt reminder of the need to produce good quality software for the "enhancement" of mathematics teaching and learning is also given by Bajpai et al [167] (p.407) because "there is a very poor balance between the developments in hardware and the software currently available for use in mathematics teaching." A set of useful guidelines is then presented for those embarking on this difficult but most necessary and immediate task.

In Ireland there is a further disadvantage as mathematics courses do not emphasize the applications value of the subject or the integral links with other subjects. Furthermore, the Department of Education has not awarded Computer Studies status as an examination subject and, as a result, the certificate it awards at Senior Cycle is of dubious value. On a more positive note, a Computer Studies Survey [168] (n = 215 Schools) carried out in 1985 in Irish post-primary schools revealed that teachers give a high priority to computer application and to the usefulness of computers in society.

No studies exist on the effectiveness of mathematics teaching in Ireland, but if pupil achievement in the state examinations is accepted as the only outcome of effective teaching, then the situation needs remedial attention. One study [169] in mathematics teaching undertaken by an undergraduate mathematics student in Thomond College in 1985 (n = 6 schools) involving 420 pupils and 22 teachers revealed:
(a) a lack of knowledge about computers and their use on the teacher's part
(b) expository style teaching was the predominant teaching method with no work on projects and little pupil participation in mathematics classes
(c) the relevance and applications value of mathematics is not being taught
(d) teaching aids were never used by mathematics teachers.

Although it is not possible to generalize from this study, the findings are particularly disturbing as they give some indication of the type of mathematics teaching taking place, which in turn has a certain "effect" on the way in which mathematics is learned. With regard to the non-use of teaching aids, it appears likely that computers will not be sold to mathematics teachers as a teaching aid, as they will not utilize them. This concern is also mentioned by Cockcroft [1] (Paragraph 406) who notes "the small amount of progress in the use of other aids which has so far been made by many teachers of mathematics".

It is now timely to integrate the understandings gained to date in the development of a model for effective mathematics teaching.

6.4.3 A model for effective mathematics teaching

It is obvious that there is overlap among the various frameworks which have been outlined above and it would seem reasonable to suggest that there will never be a set of generic teaching skills for mathematics teachers. However, from the evidence surveyed, areas of concern which contribute towards a model for effective mathematics teaching include:

- sound subject knowledge
- planning, preparation and management process skills
- climate building with pupils especially at the beginning of school year
- provision for a variety of teaching methods ranging from exposition to practical, project and investigational work
- emphasis on problem-solving, relevance and applications value of mathematics to aid understanding
- appropriate use of computers to enhance practice as an aid in promoting discussion, project, investigational and applications work along with supplementing the teaching and learning of mathematical topics
- practice of fundamental skills and routines especially mental calculations
- the ability and willingness to listen to and look much more at what pupils have to say and do in the classroom - in this manner pupils are correctly being treated as one of the determinants of outcomes and not as raw material or 'fodder'
- an increased awareness of the problematic nature of the school as an organization, and the subtle ways in which within-school factors can affect the way in which mathematics teachers teach; in addition, teachers ought to realize that the concept of school culture or ethos is more within their control than sometimes realized
- the ability and willingness to be proactive, to self-evaluate and to take responsibility for one's own personal and professional development.

This model is intended to be neither prescriptive nor exhaustive but it is utilized in the succeeding chapter in the search for serviceable appraisal techniques for mathematics teachers.

6.5 Implementation of the model: an enabling strategy

This chapter has pointed towards the complexity of teaching, and this must be taken into account when attempting to make a mathematics teacher more effective. Teaching is a dynamic process which is influenced by a variety of variables. Despite this instability, an attempt was made to arrive at a model for effective mathematics teaching. This placed particular emphasis on the process of teaching and the process skills required for effective teaching. The model also involved an awareness of our limited knowledge of in-school process factors. Notwithstanding the usefulness of the model which can act as a window on our teaching behaviours in the school-classroom nexus, effective mathematics teaching must remain a problematic concept. Brophy and Everston [170] put this cogently:
Effective teachers not only must be able to do a large number of things; they must also be able to recognize which of the many things they know how to do applies at a given moment and be able to follow through by performing the behaviour effectively.

Delivering such a model that attempts to improve the outcomes of teaching for mathematics teachers is clearly a difficult task; cutbacks in educational provision and research funding intensify this problem. Reluctant and hard-pressed mathematics teachers cannot be expected to take on such a model lightly especially the appeal to introduce micros into their classrooms. Thought needs to be given to ways of reducing the stranglehold which examinations and third-level institutions exert on the secondary sector. Changes in syllabus, much in-service education and sympathetic understanding are required if the average teacher is to harness some of the possibilities which the model offers. Furthermore, it is to be noted that a teacher’s contractual obligations are remarkably unspecific in respect of critical areas like classroom behaviour and general teacher behaviour, although there is no shortage of literature explaining how other items in the contract are to be interpreted.

The suggestions above are external ones and much more appropriate would be an examination of the ways in which the model could be taken on board by the individual mathematics teacher in a manner which could be controllable and manageable within his school context, and not to add to the many pressures and burdens already present. The aim would be to find such a vehicle that would appeal to mathematics teachers and at the same time help maximize the effectiveness of their teaching. One such strategy is the process of self-evaluation or self-appraisal (included as one of the components of effective teaching in the model). The process was recommended by the ORACLE (1975 - 80) [164] researchers and much earlier in this thesis (see Chapter 4), self-appraisal using action-research techniques was recommended as a mechanism for improving the professional position and effectiveness of the mathematics teacher.
It is the considered opinion of the author that if the Irish mathematics teacher in the secondary sector were to engage in a systematic process of self-appraisal it would contribute greatly towards maximizing the effectiveness of his teaching. It was also noted earlier that such research and professional work is necessary for a mathematics teacher to aspire to full professional status. By engaging in such a process, mathematics teachers are involving themselves in a self-validating process which will leave them in a better position to cope with the increasing demands of accountability and appraisal. Self-appraisal is essentially a proactive strategy which can help mathematics teachers monitor and improve the effectiveness of their teaching and this enabling strategy is returned to in the succeeding chapter.

Sooner or later appraisal will confront all teachers [132]: (p.91)

There is growing evidence that before very long some form of appraisal may be a part of the professional life of every teacher.

In England and Wales, teacher appraisal has been introduced with overtones of coerciveness and imposition. Teachers for the most part have found themselves entrenched in a defensive position and ill-equipped to meet the challenge, albeit one of the teacher's unions did give appraisal a cautious welcome [115]. Mathematics teachers cannot afford to sit around and wait for things to happen. There is a danger that if they adopt a passive and reactive stance they run the risk of letting a prescriptive/hierarchical appraisal scheme be imposed upon them. This power-coercive strategy will do little to enhance effective teaching, instead it could lead to frustration, cynicism and rejection. If it can be demonstrated to mathematics teachers that appraisal holds many benefits for both teachers and pupils and society at large; if it can be perceived as a valuable aid rather than a threat, then this process has a place in mathematics education. It is fair to say that while many agree that appraisal in some form
is necessary, there exists a wide diversity of views about both methods and objectives.

Thus, it appears as if the whole notion of what appraisal could and should mean warrants further investigation. The next chapter considers the more general case for teacher appraisal in a positive light. Possible appraisal techniques for mathematics teachers are suggested integrating the understandings gained from this chapter.
7.1 Introduction

Chapter 3 identified appraisal as an emerging issue of major importance for secondary mathematics teachers in Ireland. A brief examination of the current system of accountability and appraisal revealed serious drawbacks. At 'system' level, the lack of genuine external accountability in the formal sense has contributed to stagnation and lack of development within the Irish secondary sector of education. At 'coal-face' level, the analysis concluded that mathematics teachers are effectively not accountable to anybody except themselves, through their own professional integrity. In this connection, it was revealed that the inspectorate of the Irish Ministry of Education constituted an ineffective mechanism for monitoring the quality of mathematical education.

It was suggested by the author that a publicly recognized and approved system of appraisal of mathematics teachers offered a possible solution towards the aforementioned deficiencies. This discussion, together with insights gained from the previous two chapters, leads the author to formulate the following premise: that the desired improvement in school mathematics through better pedagogy can be achieved by implementing appraisal for mathematics teachers in a form which seeks to develop the professionalism of individual mathematics teachers; self-
appraisal is an essential stage in this process and is viewed as a means of maximizing potential benefits.

This premise is consistent with a major aim of this thesis - the search for serviceable strategies for an improved mathematics teaching body, one which is competent, professional, flexible and possessing the ability to respond and adapt to cultural, social, economic and technological change.

These concerns, treated in this way, have a universal appeal which transcends the country 'case study' aspect. This chapter examines and presents some of the outcomes of working through the basic premise for secondary mathematics teachers in Ireland. The issues are considered in three sections for ease and coherence. Firstly, the case for teacher appraisal is made with particular reference to mathematics teachers and teaching. Secondly, techniques to assist mathematics teachers in the appraisal process are considered; in this connection a major contribution is the presentation of a self-evaluation instrument as an aid in the key process of self-appraisal. Finally, the author details his own personal experiences of working through both self-appraisal and peer appraisal.

7.2 Mathematical Education: the case for appraisal

7.2.1 Informal appraisal: the need for new alternatives

In Chapter 3, a distinction was made between informal and formal appraisal in the Irish secondary sector and the methods by which these two types of appraisal are achieved were considered briefly. It is possible to identify a number of additional types of teacher appraisal. The 'Appraisal Tree' as shown in Figure 3 gives some indication of the myriad of forms in which teacher appraisal can manifest itself.
Formal appraisal
Informal appraisal
Organizational appraisal
Institutional appraisal
Pupil feedback
Self-appraisal
'Top-down' appraisal
'Rough' appraisal
'Crude' appraisal
Hierarchical appraisal
Mechanistic appraisal
Media feedback
Formative appraisal

Structured appraisal
Unstructured appraisal
'Sideways' appraisal
Parent feedback
Peer appraisal
'Bottom-up' appraisal
Impressionistic appraisal
Developmental appraisal
Superlatite appraisal
Organic appraisal
Dictatorial appraisal
Summative appraisal

Figure 3: The Appraisal Tree: Forms of Teacher Appraisal
Clearly, the 'branches' of the Appraisal Tree are not mutually exclusive and a number of them are synonymous: 'formal' equates with 'structured', 'superior' with 'dictatorial' etc. The present situation in Ireland can be related to the early years of the Appraisal Tree where informal or 'crude' appraisal is the dominant branch in operation. With the passage of time, the Appraisal Tree matures and many different branches emerge as suggested in Figure 3. Pruning of the Appraisal Tree is advisable to prevent a sterile phase from taking hold. In similar fashion, not all of the 'branches' will be required in the introduction of teacher appraisal. Attention has already been focused on the undesirability of a number of these branches; for example, hierarchical and superior type appraisal schemes were considered detrimental. Continuing with the biological metaphor, the Appraisal Tree will require support, care and attention in its early growth years if it is to secure a firm rooting in the ground. Likewise, if appraisal is to be introduced effectively into schools, special care and attention is required to overcome the natural suspicions and psychological fears which teachers have. The 'support' element (in terms of training, time and resources) must also be adequate to ensure successful implantation of the appraisal process at school and classroom level.

The 'appraisal' branch most pervasive in the Irish secondary sector is the informal type. Teachers are, and always have been, informally appraised by students, parents, colleagues, principals, employers, interest groups, the public and the government. This 'rough' appraisal takes place in staff-rooms, classrooms, staff meetings, parent-teacher meetings, informal conversations, and a variety of other ways and places including examination results. The resulting layers of subjective impressions can be either favourable or unfavourable, productive or unproductive. Teacher appraisal is
concerned to use such inferential opinions in a constructive manner, not to engage in self-criticism for its own sake but to use it to identify problematic areas and to suggest action steps which will enhance the pedagogy of mathematics teachers. By so doing, the ultimate hope is to improve the quality of mathematical education to pupils. As an alternative to subjective judgments and hearsay evidence, an appraisal process handled with sensitivity and empathy offers all teachers a more valid basis for decision-making regarding the teaching performance. There can be few teachers who have not, at least on some occasion, felt the lack of an objective and effective criterion by which to judge their performance. For, it is not enough to say that examinations fulfil this need as education is implicitly recognized everywhere as being more than passing examinations. A 'weak' teacher may not be receiving adequate support and 'good' teachers may be unaware of their strengths. Thus, the present system of informal appraisal is ubiquitous but haphazard and unstructured. It does not constitute an effective criterion by which teachers can judge their own performance or that of their colleagues. It is a qualitative ad hoc approach which lacks a formal procedure set against agreed criteria.

An alternative is needed to the present system which has failed to exploit the potential of appraisal for improving the teaching process. Can other branches of the Appraisal Tree contribute towards an improvement; for example can self-appraisal, peer appraisal or pupil feedback be usefully employed? Yet, any change which one seeks to effect should be an advance on current practice - it should offer 'more for less' and the innovator must be able to explain its advantages. In this connection, the author is mindful that the general principles of appraisal apply equally to all teachers of whatever subject. The concept of appraisal does not distinguish categories of appraisees. Consequently, it is legitimate to inquire if
appraisal confers any special advantages on particular groups e.g. mathematics teachers. The following positive aspects of appraisal are offered as a genuine attempt to customize appraisal for a specific target group viz. secondary mathematics teachers.

7.2.2 Positive aspects of Appraisal

1 The reduction of stress and anxiety

Mathematics teachers have had to contend with a variety of pressures and constraints due to the nature of the subject per se. One such example is in the presentation of content in a particular order as well as in a particular manner because of the hierarchical nature of the subject. They are also expected to be sensitive to the relevance of their subject to other specialist areas.

In many countries, there is a growing lack of confidence in the ability to teach mathematics successfully. One manifestation of this has been the back to the 'basics' movement. Far from accepting these pressures and constraints as intractable, appraisal has an important role to play if it can be shown, that by participating in an effective appraisal system, a mathematics teacher benefits by knowing what is expected of him. This, together with the feeling of being generally valued and appreciated, can help greatly in the reduction of stress. A teacher’s self-esteem and self-confidence can be boosted in the process. There is value in appraisal (if only of a therapeutic nature), if the process provides opportunities for mathematics teachers to talk about contextual constraints as this can help dissipate a degree of tension.

Despite the anxieties and stresses outlined, it has been
assumed that the 'carers' can care for themselves. The career structure is no longer a source of motivation and can cause anxiety and frustration for those whose careers are static. Involvement in appraisal can lead to a reduction in stress by providing a temporary palliative for mathematics teachers whose careers appear blocked in terms of more varied and interesting work, more positive job-satisfaction, improved performance in the classroom and more status as a professional [121], [127].

II Role of appraisal in a rapidly changing world

Up until the 1950’s change took place slowly and educational systems were generally small in size. However, since then, in direct response to the technological revolution, the rate at which schools have been asked to change has increased enormously and educational systems have expanded much in size. Mathematics teaching itself is being directly affected through changing pedagogical possibilities (with the onslaught of the microcomputer for example), changing demands and expectations and changing educational goals and structures. Many mathematics teachers in their quiet moments must feel that they are struggling to do poorly a job that may not be worth doing at all. To survive and grow in this world of the future will require degrees of personal competence and skills from mathematics teachers which are not modelled by the present appraisal and teacher education systems.

It is interesting to speculate the role that appraisal might have had in ending the structural approach of the 'New Mathematics' in the 1960’s at an earlier date. For it is now recognized that the structural approach was too complex and the pace at which it was presented too fast (see Chapter 2). It is not unreasonable to suggest that if a systematic process of appraisal had been on-going at the time, such lessons would have emerged at a much
earlier date from feedback channelled via teachers' and pupils' comments. Crucially such questions as: "How can we structure the mathematics curriculum to facilitate student learning?" or "What is it that we want students to learn in mathematics?" or "Why teach mathematics at all?" would have gained attention at a much earlier date. The 'structural' approach for example, provided no obvious role for application in mathematics teaching and this omission might not have persisted for as long as it did if the 'New Mathematics' had been subjected to appraisal and scrutiny as an on-going process.

Significant changes in school mathematics will not be achieved unless accompanied by a corresponding change in attitudes and perceptions in the vast majority of mathematics teachers. An effective system of appraisal which accepts the increasingly important role of the teacher in educational change will help in this transition and assist mathematics teachers develop the necessary new skills that will be expected of them. For example, target-setting as a component in the appraisal process could help mathematics teachers meet the challenge of the information revolution by identifying relevant training needs which must be met with adequate in-service education.

III Professional development.

Teaching demands much time and energy and it is easy to get caught up in its tasks. Few opportunities are presented where mathematics teachers can step back and ask some important questions about their performance. Professional growth as a result can become stunted. To say the least of it, it must be a disconcerting and frustrating experience to be working alongside colleagues who have decided that no more can be done because of the principal or because of the pupils. Mathematics teachers are no different from teachers of other subjects and often
engage in a ritual of "celebrating" the problem instead of taking a proactive stance towards improving current pedagogical difficulties. One of the fundamental benefits of appraisal is thus to prevent apathy and inactivity from becoming the norm through self-enhancement. Without such a process, mathematics teachers will remain in 'robot' mode and remain unaware if intentions and actions are matched in the teaching process.

The involvement of mathematics teachers in a more formal appraisal scheme is dependent on the credibility of the scheme that evolves. One outcome of such a scheme would be the identification by mathematics teachers of their development and remediation needs. This, in turn could lead to an improvement in the responsiveness of in-service education. This is important, as in-service education and training is a voluntary professional activity which depends for its success upon the goodwill of teachers. It is therefore vital that it should be relevant to staff needs and of high quality. A credible appraisal scheme has the capability to identify these needs, leading to improved professional development.

If full professional status is to be attained by mathematics teachers, they have got to accept increasing professional responsibility for self-improvement in order to see how they are performing. Self-appraisal or peer appraisal using action-research procedures encourages the mathematics teacher to identify and investigate problems related to his own practice and to propose, implement and evaluate remedies to improve the effectiveness of his teaching. This process can help mathematics teachers generate their own theory, thus helping to dispel the notion that teachers are not professionals as they fail to immerse themselves adequately in theory. It is a proactive approach, which is non-prescriptive, non-judgmental and under the control of the teacher to decide when to appraise and with whom. As sources of data about
teaching performance, self-appraisal and peer appraisal ought to play a role in full formal appraisal.

Notwithstanding this, it would appear that these processes have the potential to make a significant contribution to personal growth and development. These benefits are of special significance in the Irish context where the professionality of the mathematics teacher is seriously inhibited by the lack of opportunities to engage in genuine professional activities. The absence of a departmental and promotional structure combined with traditional routines and teacher isolation has led to stunted professional growth, stagnation and an introverted attitude to change on the part of mathematics teachers (see Chapter 3). As opposed to this, appraisal ought to be viewed as an empowering process enabling mathematics teachers to exercise greater personal control over aspects of their teaching. In this context of enrichment and professional support, appraisal can allay fears of a threatening process about to be unleashed on teachers.

IV Appraisal and management education

Management education in general has not been taken seriously in schools in Ireland. From the author's own experience his professional reading and in his many encounters with colleagues in various educational systems, a great deal of the present organization and management in our secondary schools can be described as ad hoc having no theoretical substructure. A systematic system of appraisal will probably reveal this more evidently. In this respect, Marland (171) (p.187) has argued correctly that appraisal ought to be linked to in-school planning and evaluation, and not viewed as an isolated activity. A combination of teacher and school appraisal has the potential to promote the concept and need for a departmental structure for mathematics teachers, for collaborative and collegial work among mathematics
teachers both as a group in a school or between schools. In this way, the developmental needs of both the mathematics teacher and the school, as identified by the appraisal process, can be met by school-based in-service education, increased professional reading and self-study and self-reflection on the part of mathematics teachers.

Thus, appraisal has the potential to help mathematics teachers develop skills in curriculum development, staff development and peer relations. These can produce a 'knock-on' effect in management practice in schools with consequent improvements for all partners in the system. Furthermore, the coherence of the school as a whole can be enhanced, as appraisal can help elicit what new roles teachers might best engage in to advance the school as a unit. By engaging in the appraisal of staff, headteachers can also benefit. They can improve their awareness of the effects that their actions can sometimes have on their own staff members. This can lead to what Sandbrook [126] (p.13), a primary head, calls a letting go of 'much more in genuine delegation'.

V Apraisal and accountability

Since the mid 1970's there has been evidence of growing disquiet over the quality of education being provided by schools. Perhaps it is not unreasonable to suggest that if appraisal of teachers is not introduced in a systematic manner, the growing trend to consumerism will do so through the courts, the media and parent associations. This public disquiet has on the one hand demanded that mathematics teachers return to more drill and exposition in an attempt to cope with new demands from administrators and concern over low standards, while on the other hand they have to contend with demands for technology and computers from both parents and students. These are conflicting sets of pressures. Thus, mathematics teachers are expected not only to be skilful in managing the
integration of stability and change but also in effectively evaluating what they are doing.

The present system of formal appraisal and monitoring in Irish secondary schools, as evidenced by the inspectorate of the Ministry of Education, is ineffective. Appraisal is a tool which can help mathematics teachers meet legitimate demands and expectations. The mathematics teacher who is engaged in appraisal is involved in a self-validating process and will have less to fear as he will be able to render an adequate account of his activities to the public in whatever form educational accountability will take in the future. Thus, as Nuttall [172] advocates, appraisal is complimentary to the accountability purpose.

Despite the choice that is still ours, many mathematics teachers will not grasp the initiative and almost certainly there will be centralized attempts to raise standards, possibly by legislation. This power-coercive approach will not result in meaningful change for mathematics teachers and must be avoided. It undermines their professionalism and reinforces the notion that mathematics teachers are powerless, docile and inactive functionaries. Appraisal takes the view that mathematics teachers, by assuming responsibility for a proactive approach to examining aspects of their teaching, can play a meaningful role in improving the quality of mathematics education through improved pedagogy. To this end, it is appropriate to examine into appropriate appraisal techniques for secondary mathematics teachers.

7.3 Appraisal techniques for secondary mathematics teachers

In order to take advantage of this opportunity to improve the quality of mathematical education for pupils, it is
necessary to build on the knowledge that exists on the nature of effective mathematics teaching. This was achieved in Chapter 6. The issue of appropriate criteria for effective mathematics teaching and the manner in which these are either agreed or imposed is crucial and must form an integral part of all appraisal techniques. The significance of this issue is reconsidered briefly, after which the author explores and examines appraisal techniques for mathematics teachers at two levels: first, Level 1 considers a number of methods for self-appraisal by mathematics teacher; secondly, Level 2 examines peer appraisal and offers a collegial technique for operation by secondary mathematics teachers. Taken together, the techniques of both Level 1 and Level 2 incorporate a "bottom-up" and "sideways" aspect respectively to teacher appraisal.

7.3.1 Criteria for effective mathematics teaching

The analysis of Chapter 6 revealed that the task of appraising teacher effectiveness and performance in mathematics teaching is problematic and demands careful attention. The search for a model identified critical areas of concern which contribute towards effective mathematics teaching; the major elements are summarized below:

- sound subject knowledge
- planning, preparation and management process skills
- provision for a variety of teaching methods ranging from exposition to practical, project and investigational work
- emphasis on problem-solving and the relevance and applications value of mathematics
- appropriate use of computers to enhance practice as an aid in promoting discussion, project and investigational and applications work along with supplementing the teaching and learning of mathematical topics
- the need to consider pupils as an important input
variable in the teaching process
- practice of fundamental skills and routines, especially mental calculations
- the ability and willingness to be proactive, to self-evaluate and to take responsibility for one's own personal and professional development.

The list suggests a set of mathematics teacher 'attributes' and, in particular, explicitly identifies process skills as important for effective mathematics teaching. This point is often missed by mathematicians who are entrusted with a significant proportion of all mathematics teaching and is less than fully appreciated by mathematics educators generally. In addition, the list draws attention to the central role of self-appraisal in promoting effective mathematics teaching since it contributes to the personal and professional development of mathematics teachers.

It has been noted in Chapter 5 that teachers are averse to externally imposed appraisal schemes where the criteria for appraisal are determined by the appraiser without contribution from the mathematics teacher as to their suitability. This can lead to mathematics teachers perceiving appraisal as a threatening process and will not lead to worthwhile changes in the behaviour of the teacher. A much more acceptable notion of agreeing appraisal criteria can be gained by recourse to a phenomenological view of social reality, where the appraiser would attempt to understand the social situation from the viewpoint of the mathematics teacher. It is a person-centred approach and it gains credence from the personal construct theory of George Kelly [173]. The latter theory emphasizes the importance that ought to be attached to the individual mathematics teacher's view of the world in which he teaches and lives. In the case of both peer and formal appraisal, this would result in the criteria for effective mathematics teaching being jointly negotiated by the appraiser and mathematics teacher before classroom observation takes place. After observation, the
emphasis switches to processing judgments, not passing them and involve mathematics teachers clarifying the meanings and values they give to what they do along with suggesting improvements for the future. In this context, appraisal has a role in enhancing effective mathematics teaching. These insights are incorporated into the following appraisal techniques which represent an attempt to move mathematics teachers beyond awareness to effective teaching through improved pedagogy.

7.3.2 Level One: Self-appraisal

7.3.2.1 Self-appraisal and mathematics teaching: a rationale

If mathematics teachers are to engage in appraisal it is essential they have a view of what constitutes effective mathematics teaching. The model of effective mathematics teaching presented in Section 7.3.1 is a preferred one, arrived at after careful consideration. It would be unwise to be dogmatic in the circumstances since teaching is such a complex dynamic process. Self-appraisal is an important feature of this model. It is also a key strategy in promoting effective mathematics teaching. The author believes that mathematics teachers can optimize their influence in the classroom by engaging in a systematic process of self-appraisal which incorporates the model to normal practice. In this way, self-appraisal is seen as a proactive strategy through which mathematics teachers monitor and improve the effectiveness of their teaching. This strategy is more likely to succeed because it does not apportion blame for shortcomings or threaten but instead appeals to individual professionalism.

There is an enormous amount of education research and management research generally which favours self-appraisal as the starting point of the total appraisal process. The
Research suggests that teachers are more likely to take action on data gathered by themselves than from other agencies. The potential of self-appraisal as a developmental and participative process has been articulated in a recent paper [174] produced by the British Psychological Society.

Judged in relation to developmental purposes, self-appraisal has very much to offer. For these purposes appraisees might be asked to assess the relative strengths of their motives, abilities or characteristics within themselves. Provided that the right conditions are met, for example that the nature of the assessment and its purpose are made clear, people can, and will, assess aspects of their ability, performance and personality and their assessments will compare very reliably with those made by others.

John Elliott, [175] (p.57) a key advocate of self-evaluation in the classroom comments:

In self-monitoring, the teacher becomes aware of the consequences of his actions and the extent to which he can be held responsible for them by reflecting about his practice.

More recently, Elliott [82] offers three levels of professional development which suggest that teaching quality can be improved through self-evaluation involving deliberation and action-research. This technique and its use in investigating and improving aspects of mathematics practice have already been discussed in Chapter 5. In short, it is a technique which is receiving increasing attention and involves teachers studying their own teaching, identifying an interesting aspect, collecting evidence about it and acting on the results followed by evaluation of the action taken. It is an approach which values the personal and individual context of the mathematics teacher and encourages teachers to reflect on their own practice in the context of the classroom.

Elsewhere [88], it has been suggested that the academic knowledge required by mathematics teachers has been
overemphasized to the neglect of the professional development of classroom processes. Self-appraisal can be viewed as one means of redressing this imbalance which exists between the extension of mathematical knowledge on the one hand and the extension of professional knowledge on the other.

It is hard to see how existing practice can be improved if the reality of that practice is not analyzed and acknowledged. If mathematics teachers are to improve what they do, they must start from what they are really doing rather than what they say they do or even what they would like to be doing. Such an analysis must surely precede any serious attempt to improve upon existing practice. This may not be a solution as such, but it is a necessary condition of any effective solution.

In summary, self-appraisal is a proactive and participative approach, emphasizing the power of the individual mathematics teacher to reflect on his own practice in the context of the classroom. Such a process can help him recognize and support effective practice, thus helping to reduce the gap between belief and reality. This stance is premised on the view that mathematics teachers will readily seek to improve their practice if they regard it as part of their professional responsibility and not imposed on them from an external source. It is reasonable to conclude, therefore, that a mathematics teacher who ‘self-appraises’ his own teaching instead of waiting for an outside appraisal to point out weaknesses will have a decided advantage when teacher appraisal inevitably arrives.

7.3.2.2 A self-evaluation instrument for secondary mathematics teachers

Motivated by a desire to maximize the effects of self-
appraisal for mathematics teachers the author decided to structure and customize the process appropriately. This dual purpose was achieved in a self-evaluation instrument (Figure 4) for secondary mathematics teachers. This instrument brings to bear on the situation considerable purposeful research into teacher appraisal, effective mathematics teaching and classroom practice. The following section headings which are adapted from Travers et al [176] form the backbone of the self-evaluation instrument and may be used as an abbreviated instrument in its own right.

A. Teaching for problem-solving and discussion with pupils.
B. Teaching for skills, facts and routines.
C. Teaching for understanding.
D. Classroom preparation and planning.
E. Professional competence.
F. Management skills.
G. General contribution to school.
H. Obstacles hindering performance as a practitioner.
I. Improvements for the future.

Broad headings on their own lack specificity and are of limited use only. They also present a difficulty in that on the surface, similar self-appraisals may mean different things for different teachers and in different schools. These nine headings are elaborated on in more detail in Figure 4. The additional descriptors are supplied to help the mathematics teacher by identifying for example, areas where help may be required or how professional development can be supported. One obvious disadvantage is the amount of time required by the mathematics teacher to complete the form together with the task of absorbing and responding to the possible consequences of the appraisal. This could give rise to motivational problems. It is suggested therefore that the mathematics teacher might first scan the headings as a general guide to his effectiveness. Particular section headings which emerge as being significant could then be considered in more
FIGURE 4

A self-evaluation instrument for secondary mathematics teachers

A. Teaching for problem-solving and discussion with pupils

1. I ask students to state problems in their own words.

2. I encourage students to understand how to apply concepts and skills being learned to problem situations.

3. I reinforce the solving of problems by:
   praising student work;
   providing investigational work,
   using the computer to enhance problem-solving skills.

4. I encourage students to suggest solutions to problems, then test their 'hunches'.

5. I call attention to applications of mathematics in industry, engineering, the sciences, and in the students' daily lives.

B. Teaching for skills, facts and routines

1. I use diagnostic tests to determine pupil weaknesses.

2. I provide the students with practice, both orally and written on the use of rules and procedures.

3. I assign time for work on mental calculations.

4. I provide drill on facts, skills and routines needed for success in subsequent learning.

C. Teaching for understanding

1. I use oral and written questions during the development of a concept to determine student learning.

2. I review class work periodically either personally or by getting pupils to do so.

3. I use my own blackboard examples and diagrams, different from those in the book, to promote understanding rather than recall.

4. I use a variety of teaching methods which help students discover answers for themselves including appropriate practical work and general problem-solving activities.
5. I encourage active participation and allow sufficient 'wait-time' for students to think about their answers before responding.

6. I use the computer appropriately to enhance learning and understanding.

D. Classroom preparation and planning

1. I plan and prepare my lessons in advance of teaching, especially at the beginning of a new topic.

2. I check out the previous knowledge and skills of pupils.

3. I contract with pupils on rules, procedures and sanctions at the beginning of the year.

4. My writing on the blackboard is clear and flows logically.

5. I use variety in my presentations: coloured chalk, diagrams, models, A/V aids, etc.

E. Professional competence

1. I set and mark homework regularly.

2. I assess the success of my lessons.

3. I give recognition to individual pupils by name.

4. I expect my students to succeed in examinations and manifest this expectation constantly to them.

5. I exhibit mathematical knowledge which is sound in quality and current (technical knowledge and skills).

6. I avail of opportunities to self-evaluate and to take responsibility for my own professional development.

F. Management Skills

1. I function in a controlled and effective manner under pressure and can deal with personal crises of credibility in the classroom (intrapersonal skills).

2. In general, my classes exhibit a businesslike approach to teaching (leadership skills).

3. In general, I am able to build relationships with pupils, peers, parents (interpersonal skills)

4. I exhibit the ability to take sensible decisions and implement new ideas (entrepreneurial skills).

5. I understand my role position and its impact on pupils and school (introspection skills).
G. General contribution to school

1. I have an awareness of the wider curriculum

2. I actively support the role that mathematics plays in advancing the aims of the school.

3. I am involved in:
   - School curriculum development work
   - Cross-curricular developments
   - Support for probationers
   - Extra-curricular activities
   - In-service education/training

4. In general, I take an active interest in the welfare of all pupils.

5. I am able to suggest changes in the school organization which would be beneficial.

H. Obstacles hindering my performance as a practitioner

1. I lack opportunities to develop as an extended professional e.g.: curriculum innovation involvement, unable to secure secondment or attend inservice training courses, etc.

2. I feel my work is not being valued in the school.

3. My workload is too great causing tension and anxiety.

4. The school and/or Mathematics Department lacks a clear rationale for development.

5. My pupils have a poor attitude to work.

6. My career needs are not being met.

7. Management and/or colleagues exert a constraint on my performance as practitioner.

I. Improvement for the future

1. I am now aware of my strengths and some weaknesses as a professional mathematics teacher.

2. I can identify clearly my targets for the coming year including strategies to help meet my developmental needs.

FIGURE 4

A self-evaluation instrument for secondary mathematics teachers
detail on separate occasions, using Figure 4 as a tool. This will reduce the amount of time necessary for the self-monitoring exercise and the mathematics teacher is less likely to abandon the form as a result.

7.3.2.3 Limitations and criticisms

It is stressed that the instrument is not prescriptive, exclusive or exhaustive. In this respect it resembles more a prescription of the process of the teacher self-appraising in the classroom with the form merely as a vehicle. More importantly, the filling of such a form will not in itself result in improvements. It is the action taken by the mathematics teacher following the exercise that really counts. As a result of first identifying the problem area and then reflecting and deliberating on the completed self-evaluation form, the action taken by the mathematics teacher can then be evaluated. The cycle can then be repeated as depicted in Figure 5. This spiral process is analogous to the action-research evaluation model as described by Kemmis et al [111].

Thus, if a mathematics teacher notes from the completed form that his question/answer skills are not promoting understanding of mathematics or if exposition is the only teaching method being used or if textbooks are the only teaching aid in question, then it becomes his responsibility to propose, implement and evaluate remedies that are within his resources. In this way, the self-appraisal of particular practices in particular contexts is more relevant to the educational and professional needs of mathematics teachers and consequently more likely to result in improvement.

The over-mechanical use of the form, which could lead to a 'teach to list' mentality, is to be avoided and if the
Figure 5: The self-appraisal spiral
procedure does not lead to self-enhancement and an increase in self-awareness then the process is a sterile one. Any attempt to include a rating scale as an integral part of the instrument has been purposefully avoided, as this would introduce a norm-referencing element which could lead to undesirable consequences for mathematics teachers. Neither is the form intended to be a prescription of what a 'good' mathematics teaching performance should be like.

7.3.2.4 Alternative techniques for self-appraisal

A. Audio

Portable audio-cassette recorders are inexpensive and are extremely useful in the self-monitoring and improvement of one's teaching. In England, the Ford Teaching Project was mainly concerned with self-evaluation in the classroom. It was noted that when teachers listened to a tape-recording of part of their lesson, the result was usually quite dramatic [177].

The use of the tape-recorder will not be an ambitious exercise. It is suggested, for example, that the mathematics teacher might record the teaching of his own mathematics lesson (or part of a lesson e.g. 10 - 15 minutes). This can take place at the discretion of the participant who then plays it back for his own private listening and analysis. Again, the self-evaluation instrument (Figure 4) provides useful guidelines for evaluating the teaching and, before the recording, the participant should agree on what qualities/criteria should be chosen and to use these afterwards in the evaluation.

Exposition is one area which lends itself easily to this monitoring technique. If the mathematics teacher, after feedback, finds out that he talks too much, then he has found that out for himself without having to be told so
from an external appraiser in a judgmental fashion. He is now aware that more constructive oral work on the part of the pupils is one strategy which can help redress the imbalance. Furthermore, the research surveyed earlier on the merits of self-appraisal suggested that teachers are more likely to act on 'self-gained' data than that from any other source. Question and answer skills, pace of lessons along with teacher-pupil interaction can also be investigated using the tape-recorder. As the mathematics teacher becomes more familiar and confident, he should be able to identify appropriate elements for himself.

The reality presented by such methods rarely corresponds to what the teacher believes is happening. Thus, one of the major advantages of the self-monitoring process is that mathematics teachers are helped to appreciate the difference between belief and reality and, as a result, significant advances in classroom techniques can be made. The importance of action taken is again an essential feature for success to take place. This action can subsequently be evaluated to see if improvements are taking place. The process can then restart in cyclical fashion as indicated in Figure 6.

B. Video

Virtually all secondary schools are equipped with good video facilities and this aid can be most valuable as a self-appraisal technique. Familiarity with the mechanics of how to use the machine is important, otherwise its use may be disruptive, frustrating and disturbing. The principle is much the same as described above using the tape-recorder. However, a videotape recording gives a more complete picture and allows the mathematics teacher to record the teaching of his own lesson (a trained senior pupil can help here), and to use it for private observation and analysis. A major advantage is that the psychological fear of feeling inferior is avoided as the
Figure 6: Cyclical self-appraisal using the audio tape-recorder
process is private to the mathematics teacher who can terminate it at will. Other advantages include accuracy of recall and repeatability of incident.

In common with the tape-recorder, the self-evaluation instrument can be used to help in the evaluation of the recorded teaching. Similarly, the criteria should be identified before the lesson is taped and these criteria can then be used in the self-deliberation which follows afterwards. As confidence and familiarity increase from repeated observations and analysis, the individual mathematics teacher will identify particular categories of teaching relevant for his own improvement, leading to the creation perhaps of an amended or a new self-evaluation form.

The videotape recordings are particularly useful for observing the effects of a teacher's actions on his students, for example, whether questioning techniques are having the desired effect or the extent of verbal and non-verbal communication between teacher and pupils. Skills such as recognizing student behaviour, opening and closing of lessons can be analyzed and self-improvements suggested. In all cases however, the feedback should be followed by appropriate teacher action on the problem area identified. Finally, before the cycle is repeated, the action taken should first be evaluated. Videotape can thus act as a supplement to self-appraisal and enhance the interpretation of the teaching/learning process.

C. Feedback

As confidence grows from the techniques explored above, the individual mathematics teacher may now invite his pupils to do some appraising of his efforts. It would be odd if pupils (who are the consumers) did not contribute to the appraisal process. Chapter 4 drew attention to the need to consider pupil attitudes as a significant input
variable in the teaching and learning of mathematics, while Chapter 6 indicated a need to consider pupils as important determinants of effective outcomes in the classroom context. Examination results, while important, ought not to exclude and reject pupil feedback on the grounds that it is unreliable and trivial. On the contrary, valuable feedback is obtained by the natural, unplanned-for responses of pupils that form part of day-to-day teaching. Their smiles, gestures and postures are all signals which can indicate how the mathematics teacher is doing. The cultivation of this skill of learning how to 'read' a class comes from experience and an able teacher recognizes that each class differs from the next. Some possible techniques are explored below.

(1) Oral or written feedback

The mathematics teacher can simply ask the pupils to express either orally or in writing how they think he is performing as a teacher. Courage on the first few occasions is necessary since pupils are often very honest in their answers and this technique should not be used if you are not prepared to accept what they say (and without making defensive judgments in response!). From his case study on pupils' attitudes, the author would state that students are usually very fair and honest in their comments, providing much insightful and helpful information.

(2) Questionnaire

This is a more structured method of getting pupil feedback and one example of such a student questionnaire is the Teacher-Image Questionnaire developed at Western Michigan University, U.S.A. and discussed in the mathematical context by Travers et al [176]. It is not suggested that
such questionnaires are in a suitable form for Irish secondary mathematics teachers. The individual mathematics teacher concerned can modify the questionnaires and determine which qualities he would like his pupils to use in the appraisal process. This process of refinement does not require a great deal of creativity. An example of what an adapted version of the Michigan Questionnaire might look like appears in Figure 7. The author has used this adapted version in his own school with sixty pupils in their second year of the post-primary cycle. Each circled item in Figure 8 represents the modal choice by all sixty pupils for that particular variate. Taken together, the trend profile as shown in Figure 8 is arrived at which gives an indication of the author's teaching performance as perceived by his own pupils. Pupils should be informed that the purpose of the questionnaire is to help the teacher find out how he is doing and pupils should be assured that normal standards of confidentiality will be adhered to.

7.3.3 Observations on Level One appraisal

It is appropriate to summarize some of the benefits and limitations of the techniques explored in Level One. Self-appraisal appears to place a professional obligation on all mathematics teachers to be concerned with self-improvement. This professional development model involves the mathematics teacher as researcher in the classroom. It is a research activity which has been favoured by the Research Group of the Association of Teachers of Mathematics as an in-service activity. Also, there are indications that research in mathematical education appears to be moving away from the positivistic paradigm with a consequent shift in emphasis from quantitative to qualitative approaches [178]. Self-appraisal, using the Level One techniques described above, is essentially qualitative in nature and can thus help reduce the gap
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<tbody>
<tr>
<td>1.</td>
<td>Sound knowledge of subject.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>2.</td>
<td>Good planning, organisation and management skills.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>3.</td>
<td>Fairness in treating all students in class.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>4.</td>
<td>Shows control in class yet there is a friendly relaxed atmosphere.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>5.</td>
<td>Relates mathematics to outside class and everyday life situations.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>6.</td>
<td>Listens to what students have to say in class.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
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<tr>
<td>7.</td>
<td>Encourages students to raise questions and express ideas in class.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>8.</td>
<td>Teacher is enthusiastic and enjoys his teaching.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>9.</td>
<td>Has a sense of humour - can laugh at his own mistakes.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>10.</td>
<td>Exercises are too long...</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>11.</td>
<td>Marks exercises regularly.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>12.</td>
<td>Does not over-react when little problems arise in class.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>13.</td>
<td>Teacher is patient, courteous and considerate.</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
<tr>
<td>14.</td>
<td>My mathematics teacher is an effective teacher overall</td>
<td>YES!</td>
<td>Yes</td>
<td>yes?</td>
</tr>
</tbody>
</table>

Figure 7: An adapted version of the Michigan teacher-image questionnaire
<table>
<thead>
<tr>
<th>Statement</th>
<th>Yes</th>
<th>Yes?</th>
<th>No?</th>
<th>No</th>
<th>NO!</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sound knowledge of subject.</td>
<td>YES!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Good planning, organisation and management skills.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>3. Fairness in treating all students in class.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>4. Shows control in class yet there is a friendly relaxed atmosphere.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>5. Relates mathematics to outside class and everyday life situations.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>6. Listens to what students have to say in class.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>7. Encourages students to raise questions and express ideas in class.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>8. Teacher is enthusiastic and enjoys his teaching.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>9. Has a sense of humour - can laugh at his own mistakes.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>10. Exercises are too long.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>11. Marks exercises regularly.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>12. Does not over-react when little problems arise in class.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>13. Teacher is patient, courteous and considerate.</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
<tr>
<td>14. My mathematics teacher is an effective teacher overall</td>
<td>YES!</td>
<td>Yes?</td>
<td></td>
<td>No</td>
<td>NO!</td>
</tr>
</tbody>
</table>

**Figure 8: Pupil Feedback: Trend Profile of author’s teaching performance**
between mathematics teacher and researcher, between practice and theory.

Self-appraisal enables the mathematics teacher to examine and identify problems or interesting aspects of their teaching such as classroom management, methodology and teaching styles, professional attitudes, concept development, use of the microcomputer and other important concerns. Many of the areas of concern which the mathematics teacher will highlight for improvement will be self-rectifiable as in the case of blackboard writing, voice control or questioning techniques. The techniques of Level One appraisal (with the exception of pupil feedback) do not require mathematics teachers to overcome the psychological fear of having to expose their 'weaknesses' to others. Goal-setting as a result can be more motivational and productive. Experience of such techniques indicates that teachers who take part raise their morale and increase their effectiveness [166]. One of the techniques suggested a method whereby pupils could play a part in teacher self-appraisal and this is to be welcomed.

Apart from the constraint of time which has already been mentioned, it can also be painful for mathematics teachers to realize that some of their long established beliefs and implicit theories of learning mathematics are of little benefit. However, the promise of involvement in self-appraisal is one of personal growth and development and more effective teaching performance through improved pedagogy. As the mathematics teacher becomes more familiar and confident he will discover categories of teaching behaviour important for his success. It is therefore possible and desirable for mathematics teachers to devise their own evaluative instrument and to practise these skills as well.

Any evaluative procedure will only succeed if it can be
shown that it will involve mathematics teachers in a participative role and in aspects of their practice that affects them personally [179]. Self-appraisal appears to meet these requirements. Although it has a great deal to recommend, it is accepted that the link between professional development and change has not been empirically validated but for the purpose of this thesis, the link between both is not questioned. Support for the view has been generated by the growing evidence of teachers' case studies using action-research techniques for those genuinely concerned with the improvement of pupils' learning through increased teacher effectiveness.

In many countries, self-appraisal on its own would lack credibility as a major source of data for performance appraisal. However, as an initial stage in formal appraisal, the mathematics teacher is engaging in a professional and enriching process which can lead to more job-satisfaction, an increased self-awareness, more personal control over the teaching process and thus more effective mathematics teaching through improved pedagogy. Finally, the evaluation instrument and other techniques explored are likely to be modified, improved and refined as a result of testing/pilot procedures.

7.3.4 Level Two: Peer Appraisal

7.3.4.1 A rationale for peer appraisal

Self-appraisal involving only the teacher himself has its limitations and a stage will be reached when the novelty of watching even yourself will wear off! It may occur to the mathematics teacher that as a result of concentrating solely on the effect of his own actions as a teacher he has neglected to give due consideration to what the children are doing. What children are receiving his
attention? How are they responding to his variety of teaching methods (if he has a variety!). Are there areas of the classroom which he tends to ignore? The mathematics teacher will profit from having a capable, experienced colleague (preferably a mathematics teacher) as an observer, who will point out behaviours, activities and cues which the mathematics teacher may not have noticed. Lesson observation by a peer can thus provide useful information for those concerned with formal classroom observation.

In another sense, peer appraisal is a logical extension to the self-monitoring process of Level One. As the confidence grows from Level One, the mathematics teacher will be more likely to approach and ask a friendly colleague to observe and criticize his classroom performance. This gradual process will help him to overcome the natural fears and suspicions surrounding an appraisal process which requires him to admit areas of 'weakness' to others. Lesson observation seems then to be both sensible and likely to prove supportive and helpful. However, research does not fail to address a number of important concerns:

- the skills needed for classroom observation
- the need for an adequate sample of lessons to be observed
- the frequency of such observations
- the documents to be used for appraising classroom performance.

It is assumed that as the teachers engaged in peer appraisal become acquainted with the techniques which follow, their observation skills will improve. The frequency of such visits will depend entirely on the individual mathematics teacher. He is in control and is thus able to choose the occasion and how often it is to occur. Suggested techniques are described shortly for this level of appraisal. An essential principle of peer appraisal, irrespective of the technique utilized, lies in
the necessity for the mathematics teachers involved to decide and agree on appropriate criteria/qualities for evaluating the teaching.

This process of negotiation and mutual agreement will take place before classroom observation. This is particularly important as even experienced teachers can be apprehensive and feel threatened about the prospect of classroom observation when the criteria are determined by the appraiser without any consideration of their suitability to the teacher concerned. Peer appraisal is one example of collegiality among professional mathematics teachers and first attempts at any such processes of collaboration are always hesitant, but once the initial steps have been taken, confidence is likely to grow. Peer appraisal should enable mathematics teachers to identify the positive aspects of their practice and as Montgomery [180] (p.3) puts it "enable people to grow from their strengths".

If the mathematics department of the school establishes peer appraisal as a normal tool, it may well have considerable significance for cohesion and unity within the department, quite apart from the sharing of ideas and experiences. Regular peer and faculty meetings to report on appraisals and observations of each other’s lessons combined with discussions on agreed topics can develop insights sharpened by a certain amount of content competence. If used regularly, the strength of this method is in the systematic use of regular focused discussion. Together with the data gathered from the self-appraisal process, it can help provide those involved in the formal appraisal of mathematics teachers with a more valid basis for decision-making. Finally, what is often needed is an occasion for thinking about teaching. In Ireland this is not included as part of a school’s policy for the professional development, improvement and effectiveness of its teachers. Peer appraisal can help
fill this gap. Some possible techniques for peer appraisal are now discussed.

7.3.4.2 Peer appraisal: a collegial technique

In Chapter 5 it was noted that teachers have an inbuilt resistance to being observed in the classroom when the criteria are imposed by an external appraiser. In this context, Selmes’ [134] non-hierarchical model referred to in the same Chapter has much to recommend and avoids the hostility and suspicion associated with the usual superordinate schemes. Selmes attempts to attract teachers into the process of peer appraisal by agreeing the qualities on which they wish to be judged. This process of negotiation and mutual agreement takes place before classroom observation. These agreed criteria form the basis for classroom observation but only provide the 'raw data' for the discussion which follows. The aim of the discussion is to encourage teachers to consider changes necessary for improvement. This collegial type process utilizes a technique pioneered by Rolph [137]. After both teachers have mutually agreed on the criteria to be evaluated the technique involves the production of a simple evaluation sheet which is used and completed by both teachers on a reciprocal basis. Selmes [134] (pp. 193 - 195) then describes how Rolph's [137] evaluative technique can be adapted for a collegial model of peer appraisal in four functional stages. These stages are listed below and require no further modification for use by mathematics teachers on a regular basis.

Stage 1: Teachers agree mutually what aspects of their teaching will be evaluated (i.e. the purpose of the appraisal).

Stage 2: Teachers jointly agree the criteria/qualities to be evaluated. These negotiated criteria form the basis of a simple evaluation sheet which is then constructed. These sheets are
completed during classroom observations on a reciprocal basis by the teachers concerned.

Stage 3: The evaluation sheets provide the 'raw-data' for the next stage—deliberation and discussion. The focus here is for the teachers concerned to aim to talk about the values which account for their differing perception along with suggesting ways for improvement. Value judgments about the 'correctness' of the teaching is not the intention, although this may well be an outcome of the discussion.

Stage 4: In this final stage, a summary document is produced which makes explicit the changes needed for future improvement. A further purpose of the document is to note the amount of agreement/dissension about the observed teaching.

7.3.4.3 Limitations and criticisms

Selmes notes that when teachers are quickly asked to write those qualities which they would like a peer to use in reciprocal observation, they are identified at ease. He gives an example of some qualities agreed by one pair of teachers [134]: (p.194)

The Lesson:
- had clear aims and objectives
- had appropriate aims and objectives
- was well prepared
- showed good management of resources.

The evaluation sheet which followed required the teacher to circle the appropriate word for each quality.

This element

1. had clear aims and objectives
   YES! Yes yes? no? No NO!

2. had appropriate aims and objectives
   YES! Yes yes? no? No NO!
3. was well prepared
   YES! Yes yes? no? No NO!

4. showed good management of resources
   YES! Yes yes? no? No NO!

When trying to decide on the quality teachers may find it helpful to have a prompt list which they could use if difficulty arose. One such list might be the section headings from the evaluation instrument (figure 4) which has been discussed under Level One appraisal. A shorter and amended version could take the following form:

AIMS
   Clarity of aims
   Appropriateness of aims

PLANNING
   Organization of the lesson
   Selection of content
   Selection of materials

PERFORMANCE
   Beginning the lesson
   Variety of presentation
   Pacing of the lesson
   Pupil participation and attention
   Ending the lesson
   Teacher-pupil rapport

EVALUATION
   Use of evaluation to improve teaching and learning

PROFESSIONAL ATTITUDE
   Self-determined professional development and attitudes

In common with the self-evaluation instrument this list is not intended to be prescriptive or absolute, rather a guide and normally both participants should be capable of arriving at an agreed list of criteria without great difficulty.

Selmes considers the third stage of discussion and reflection to be particularly important [134] : (p.193)

They afford the opportunity for the teachers to discuss what was happening and why it was happening, and also encourage consideration
of the changes necessary for improvement.

Selmes' evaluative technique does not appear to include an evaluation of the new action taken, and in common with the techniques suggested in Level One, this aspect ought to feature as a component. With this element included, the cyclical process is given in Figure 9. The substantial advantages of this collegial technique for peer appraisal can be summarized as follows:

- Prescriptive criteria are not imposed by the 'experts'; instead the mathematics teachers themselves decide the qualities on a collegiate and negotiated basis, thus avoiding misunderstandings later.

- As the making of value judgments about the appropriateness of the teaching is not the focus, the process is less threatening than conventional 'external' appraisal.

- The evaluation sheet is of a simple nature.

- The process is ongoing, formative and interactive and its participatory nature maximizes teacher involvement.

In addition, Selmes notes that the technique can facilitate pupils' opinions and their attitudes to the teaching process.

The technique, including the production of the simple evaluation sheet, is relatively simple but time to carry out the appraisal process effectively is the obvious constraint. However, Rolph [137] did find that dissemination of the procedure by experimental methods and practice was relatively quick. The Ministry of Education in Ireland has a role to play here as in-service days (of a workshop nature) need to be allocated to explain the process to teachers. After that, teachers could arrive at Stage 2 and produce a simple evaluation sheet during a free period and then arrange to observe the teaching followed by the discussion and production of a summary.
Agree purpose and aspects/elements of mathematics teaching to be evaluated

Implement and evaluate action taken

Produce a summary of the discussion and plan changes necessary to improve the quality of mathematics teaching

Agree mathematics teaching criteria/qualities to be evaluated and make out an observation schedule

Identify differing perceptions and discuss values which account for this. Suggest ways for improvement.

Figure 9: Cyclical process for peer appraisal (Adapted from Selmes 1986)
The procedure can be changed and improved upon through experience but the importance of keeping intact 'the individual nature of a person's perceptions of the world in which he/she lives and works' is paramount [154]. The above system, if carried out in the correct spirit, appears likely to increase the self-awareness levels of the participants which is an essential first step before any new skills can be acquired. This, in turn, can lead to improved pedagogy and thus more effective mathematics teaching.

It would appear that this collegial technique is a professionally enriching process if it is introduced and implemented as an on-going and formative process. Furthermore, there is little cost involved which must be a highly significant consideration in the current climate of financial stringency. However, a cautionary note is provided by Selmes [134]: (p.195)

Rolph's procedure is not a panacea to make teacher evaluation painless and comforting, but it does seem appropriate for a complex task, and one which seems likely to increase self-awareness and self-enhancement, and to have the potential to increase trust and confidence in fellow teachers.

This fostering of trust and openness is vital in order to overcome the psychological fears and natural suspicions which all teachers have of appraisal.

7.3.4.4 Video and Peer Appraisal

It is not necessary to engage in a detailed explanation of this technique. Keeping the principle of the individual teacher's perceptions of teaching in the foreground, the procedure is similar to the technique just described. Peer appraisal using the video, incorporating an adapted version of Selmes' collegial technique, is given below in five stages. It is to be noted that mutual agreement of
the criteria beforehand is once more an inherent feature of the process.

(1) Decide beforehand the values and intentions/purposes of the teaching from which emerge the criteria for evaluating the teaching.
(2) Videotape the lesson(s).
(3) Feedback leads to a discussion afterwards using the criteria to identify gaps between belief and reality.
(4) Changes which are needed to reach the desired intention can then be suggested and explored.
(5) Evaluate the new action taken and repeat the cycle at will.

The video can be thought of as a supplementary aid to colleague observation enhancing the analysis and interpretation of the elements of the teaching being appraised. Mutual confidence in this technique can be developed by peer commitment and reciprocal involvement on a regular basis. If teachers have been accustomed and familiar to the video, they are less likely to be inhibited by the technology. In conclusion, colleagues, with the aid of a video, can give much to each other to aid self and professional development and enhance teaching effectiveness once initial shyness has been overcome.

7.4 Practical experiences with aspects of appraisal

In this section, the author describes his own personal experiences, and those of other secondary mathematics teachers, of working with self-appraisal and peer appraisal techniques.

7.4.1 Self-appraisal

The author, keen to elicit feedback on the self-evaluation form at 'grassroots' level, invited four experienced mathematics teachers (Mike, Eddie, Liz and Jim) in Irish secondary schools (various locations) to use the instrument over a one-week typical teaching period during their mathematics classes. Feedback was obtained by
means of a simple 'reaction-checklist' questionnaire (Appendix H).

All of the mathematics teachers perceived self-appraisal to be a worthwhile process and that the instrument was beneficial in this context. The following comments relate to positive aspects of the instrument as seen by the four mathematics teachers over the week:

I. It has helped me become more aware of my role not only as teacher but of my relationship with my students. This is an area for future improvement in my case.

II. It helped generate reflection on how I was being received in my lessons by the pupils and my overall effectiveness. It certainly encouraged me to 'stay awake' and sharpened my awareness of neglected areas with regard to effective mathematics teaching e.g. lack of emphasis on applications of mathematics to pupils' own lives.

III. It has certainly made me more aware of some deficiencies in my day-to-day teaching.

These comments accord with the author's own personal experience of using the instrument over a longer period of time. The author found that after first scanning through the form, one or two of the section headings (Sections A and F in this instance) provided a suitable focus for more detailed attention. The additional descriptors contained under Sections A and F were required by the author for a more detailed and more meaningful self-appraisal. Mike also favoured this need for more detailed elaboration:

I would not agree that the section headings alone are sufficient and I would favour even more detailed spelling out of what each involves.
In particular, Mike felt that the section headings on their own are too broad and vague to be of any real use:

To most of us, phrases such as "teaching for understanding" are very vague and can easily be skipped over, as we assume that this is what we are doing all the time. If "teaching for understanding" is elaborated out, we will probably find that we are not doing as much as we should in this area. This would apply to all of the other section headings too.

When constructing the instrument, the author purposefully avoided any attempt to introduce a rating-scale for reasons already referred to in Section 7.3.2.3. Mike, however, disagreed with this and argued positively for its inclusion:

I would prefer to see some sort of a 'rating-scale' for each question. The totals for each section would help to pinpoint weaknesses.

A primary concern of the author in relation to the self-evaluation instrument was its length which he anticipated might give rise to motivational problems. However, only one teacher (Eddie) thought the form was too long. Nevertheless, the time constraint which accompanies self-appraisal was perceived to be significant by Jim:

The time constraint - width (time) and depth (self) - going into the appraisal would need to be professionally weighed, especially the time investment, that is, how much time of the teacher is used/needed for the appraisal.

The author himself has found neither the time constraint nor the length of the form to be major obstacles. Perhaps his own personal commitment to the exercise partly explains why this was the case.
Suggestions for an extension of the self-appraisal process were received from Eddie and Jim who emphasized that self-appraisal using the instrument could be enhanced if used in conjunction with a colleague and feedback from pupils:

I think it may well be best to have this self-appraisal with a fellow teacher where more useful insights will come to light.

I don’t think the self-appraisal instrument should be isolated from the direct feedback from students. Brilliance likes confirmation!

In Section 7.3.2.3 the author stressed that the instrument was not intended to be exhaustive. Both Liz and Mike, while accepting this claim, did draw attention to a number of omissions:

There is no mention of affective objectives (developing a positive attitude towards mathematics) nor is there much recognition of the pressures that teachers are under to produce exam results.

I would favour a detailed elaboration of the section on building relationships with pupils, peers and especially parents, as this is an area in which teacher competence and professionalism is very often unrecognized.

In conclusion, the feedback on the utility value of both the self-appraisal process and the instrument was positive and beneficial. Liz’s final comment is encouraging:

The concept of a self-evaluation instrument is long overdue and your form is a step in the right direction. It will benefit mathematics teachers in their teaching and improve their professional standing in the eyes of society.
7.4.2 Peer appraisal

The four stage approach to peer appraisal, as described in Section 7.3.4.2, was attempted by the author in his own school with an experienced mathematics colleague (Jim). The author's decision to invite Jim to act as his 'reciprocal partner' in the peer appraisal process was deliberate. The author had established a good working and professional relationship with Jim and consequently did not feel frightened at the prospect of having him act as observer in his classroom. Notwithstanding this, the author, conscious that Jim was regarded as a 'sensitive' teacher, invited him first to do the 'appraising' and if he (Jim) had no objections that the author would repeat the process in Jim's classroom. This approach met with Jim's approval.

The four stage approach to peer appraisal was explained to Jim during a coffee break. It was decided by both teachers to hold both observations on the same day so that the one post-observation discussion and dialogue would suffice. It was further agreed that the lesson to be observed by both teachers would be a typical mathematics lesson that would not involve altering one's normal teaching style or modus operandi in the classroom. Finally, both participants decided to make every attempt to remain inconspicuous and to make the observations as unobtrusive as possible. Jim also felt it important that pupils should be made aware of the presence and purpose of the 'unexpected visitor' in the classroom. This was to be achieved by a brief acknowledgement at the beginning of the class. Details of the reciprocal appraisal are now described.

A. Peer appraisal of author's lesson by Jim

The author's lesson related to one of the conventional concurrency theorems. The aim was to prove that the internal bisectors of the angles of a triangle are concurrent and to give pupils an opportunity to do some
practical exercises. The pupils were a second stream class in their third year with an average age of 14/15.

Both stages 1 and 2 - that of determining the purpose and negotiating the criteria for observation - were completed during the coffee break. Both participants agreed that the purpose of the exercise was to observe the author's lesson with a view to making explicit changes which could enhance future mathematics teaching. The process of negotiating the criteria for observation was completed much faster than the author anticipated - less than five minutes - and concluded with a list of six criteria which formed the basis of a simple evaluation sheet. This sheet, together with Jim's recorded observations, is shown below.

The lesson:

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>had clear aims and objectives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>YES</td>
<td><strong>Yes</strong></td>
<td>yes?</td>
<td>no?</td>
<td>No</td>
</tr>
<tr>
<td>2.</td>
<td>was well prepared</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>YES</td>
<td><strong>Yes</strong></td>
<td>yes?</td>
<td>no?</td>
<td>No</td>
</tr>
<tr>
<td>3.</td>
<td>required pupils to transfer mathematical knowledge gained elsewhere to the task on hand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>YES</strong></td>
<td>Yes</td>
<td>yes?</td>
<td>no?</td>
<td>No</td>
</tr>
<tr>
<td>4.</td>
<td>showed pupil participation and attention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>YES</td>
<td><strong>Yes</strong></td>
<td>yes?</td>
<td>no?</td>
<td>No</td>
</tr>
<tr>
<td>5.</td>
<td>had an appropriate beginning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>YES</td>
<td><strong>Yes</strong></td>
<td>yes?</td>
<td>no?</td>
<td>No</td>
</tr>
<tr>
<td>6.</td>
<td>showed good teacher-pupil rapport</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>YES</strong></td>
<td>Yes</td>
<td>yes?</td>
<td>no?</td>
<td>No</td>
</tr>
</tbody>
</table>
Immediately before the observation, the author did feel somewhat apprehensive. When the lesson got started he felt less tense but was still conscious of Jim’s presence.

The third stage - that of deliberation and discussion - took place in the author’s house later that evening at 7 pm. Jim felt he would have been too tired immediately after school to attempt the post-observation dialogue.

Much discussion centered on items 4 and 5. Jim initially felt that pupils were not 'tuned in' during the first few minutes of the class as some pupils were still settling down. Shortly after, it emerged that his inference was incorrect as evidenced by the ability of various pupils to answer questions relating to material covered at the beginning of the lesson. Thus, Jim and the author agreed that physical movement is not necessarily an indication of inattentiveness.

Jim also pointed out that some transitions between one activity and the next were less than effective as was his level of awareness when working at the overhead projector.

The author did not experience any dissonance or negative feeling during this feedback which he attributes entirely to the openness and trust that existed between himself and his colleague. Positive feedback related to such features of his teaching as teacher-pupil rapport, willingness of pupils to ask questions and the use of the overhead projector as a teaching aid. In relation to the practical exercises, Jim was of the opinion that they did not sufficiently challenge the more able pupils. Finally, both teachers agreed that the observation was unobtrusive and both expressed surprise at how unaffected pupils were at the presence of the 'stranger'. No comments were made by any pupil during the class in relation to the exercise.

The fourth stage required both teachers to make explicit
suggestions for future improvement. This stage together with the previous one took approximately thirty minutes. After a 'brainstorm' the following questions were generated as a guide towards the future improvement of the author's teaching. They related to two areas of concern arising from stage 3.

Lesson beginning:

Do lessons begin promptly and with clarity?
Are late-comers dealt with appropriately?
Is everyone paying attention?
Is the purpose of the class lesson made clear?

Transitions between activities:

Is the noise level kept to a working level?
Are all pupils clear about what they are going to do next?
Can you anticipate any difficulties that might arise during transition phases?

Since receiving this feedback the author has been more conscious of the areas of concern noted above and has given deliberate attention to:

- effective lesson beginnings
- clear instructions and explanations during transitions from activity to the next
- increased vigilance and awareness while working at the overhead projector

Comments made by both teachers regarding the process in general are considered at the end of this section.

B. Peer appraisal of Jim's lesson by the author

Jim's class was a Leaving Certificate Honours mathematics class (top stream in Final Year) with an average pupil age
of 16/17. He espoused the following two aims for his lesson:

1. to check homework related to the following question
   Find the real root of the equation:
   \[ x^3 - x^2 - 2x - 4 = 0 \]
2. to explain the difference between unique, non-unique and infinite solutions for linear equations in three dimensions.

In common with the author's lesson, Stages 1 and 2 were completed during coffee break. The purpose of the exercise did not differ from that of the author's lesson. Once again, the process of negotiating and agreeing on suitable criteria for the observation (Stage 2) was fast, taking only a few minutes. These criteria are given below on the completed evaluation sheet together with the author's recordings.

The lesson:

1. had an appropriate beginning
   YES [Yes] yes? no? No NO
2. showed a distinct emphasis on checking for understanding
   NO [Yes] Yes yes? no? No NO
3. showed a distinct emphasis on problem-solving
   NO [Yes] Yes yes? no? No NO

The third stage of deliberation and discussion took place later that evening in the author's house. Together with stage 4 it took about half an hour to complete. Jim's first comment was:
Although I felt the class was a 'normal' one, I was always conscious of your presence at the back of the room. It kept me more awake and I was concentrating very hard. I think it affected me much more than the pupils - they didn't react at all.

There was little disagreement on the three criteria initially agreed upon. However, the absence of an application for a real root was pointed out by the author to Jim. Jim agreed that this was an area which merited improvement in his future mathematics teaching. He agreed that without this emphasis mathematics is likely to be viewed as an abstract, mechanical and procedure-based subject with negative implications for motivation and attitudes.

The author also pointed out that during the class, no questions were asked by pupils although Jim made many precise interventions himself. Some time was spent discussing this aspect and whether pupils might have been too afraid to ask questions. The author got the distinct impression that this feedback was thought-provoking for Jim.

Positive feedback received by Jim related to very high pupil concentration, precise questioning, an ability to sustain a line of questioning, economy of language and getting pupils to verbally express what they wanted to do in mathematical symbols.

In Stage 4, both participants agreed on three suggestions for the future improvement of Jim's teaching:

1. Invite questions and comments from pupils. The inclusion of 'comments' was deemed to be important as it does not suggest that the teacher is the supreme answer-giver.
2. To strive to make the teaching of mathematical topics more applicable.

3. To try out a variety of additional teaching aids including the overhead projector and the calculator.

A number of general comments and observations on the process of reciprocal peer appraisal were noted by both participants. Peer appraisal can be arranged informally over coffee break without the prior permission of the headteacher. Some advance preparation and scene-setting is necessary to make the observations as unobtrusive as possible. The exercise caused no disruption to the normal classroom routine and pupils did not react in unusual ways to the 'stranger'. Although willing to observe on a reciprocal basis, both participants did admit to feeling somewhat apprehensive before their respective observations.

The 'trust' element is a *sine qua non* for effective feedback reiterating the importance of the psychological dimension in any appraisal process. The receiving of positive feedback and praise was found to be pleasing by both teachers. Both participants expressed surprise at the ease at which criteria for observation were arrived at together with the simple evaluation sheet. This activity took about five minutes. It was felt that 30-40 minutes for each person was sufficient for Stage 3 and 4 to be completed. Although both these stages took place in the author's own house outside school hours, it is questionable if this would occur with less committed teachers. One obvious arrangement is to use a free class period for the post-observation dialogue as a means of overcoming this obstacle.

In both cases feedback was received on the same day as the observations and this was perceived to be beneficial. Jim felt that classroom observation is a skill in itself which
can be improved with training and practice. Both participants agreed that they learnt from the other person. The author was impressed with his colleague's ability to communicate in an economical and precise fashion and his insistence that pupils did not write while he was either explaining or writing on the board. On the other hand, Jim felt that the author's questioning techniques, the teacher-pupil relationship together with his use of the overhead projector were effective.

In conclusion, it was agreed that the exercise was a salutary experience which, with increased usage, could become a useful tool for the improvement of 'routine' mathematics teaching.

7.4.3 Peer appraisal and the Video

At classroom level, the author has made use of the video for peer appraisal on a reciprocal basis with a colleague (the remedial teacher) in his own school. Technical problems did not present difficulties as the school has a group of senior pupils trained in the mechanics of videotaping. This may be exceptional but it is one suggestion which other schools might implement. It is doubtful if the author would have proceeded without this facility. The author's lesson related to the teaching of mappings and the composition of functions. It had two aims:

1. to revise the concept of a mapping
2. that pupils will understand how the composition of two functions f and g is achieved.

The pupils were a second stream class in their Third Year preparing to take the Honours Intermediate Mathematics Examination. The lesson recorded was a typical one and no attempt was made by the author to vary his normal teaching
style or increase his 'normal' amount of preparation. Advance booking of the video facility was required. The pupils in the class had been alerted to the impending exercise and its purpose. It took almost five minutes before the 'video crew' (senior pupils) were ready to record. It was impossible to avoid this disruption. The pupils did appear excited and were much more energetic than normal. Some pupils did ask the author to show them the video at a later stage.

The author did not feel inhibited by the technology nor did he feel the same apprehension as when Jim observed his lesson some time previously. Nevertheless, he was conscious of the video and his level of concentration during the class was higher than usual.

Following the videotaping, the author insisted that he should first view the recording on his own a number of times. He then invited the remedial teacher along with two of his mathematics colleagues to analyze the recording using the now familiar four stage approach. This took place after school, almost a week after the initial recording. The viewing together with the post-observation discussion took one hour.

The author asked the group to 'appraise' his performance using three criteria which formed the basis of an evaluation sheet:

The lesson:

1. had an appropriate beginning
   YES Yes yes? no? No NO

2. showed an emphasis on checking for pupil understanding
   YES Yes yes? no? No NO

3. was well paced
   YES Yes yes? no? No NO
The deliberation and discussion stage resulted in the author receiving the following feedback on his teaching performance:

- explanations and instructions were unclear at certain times in the mathematics lesson; the author has since been conscious of this and attempts to be more precise have helped to redress the imbalance.
- twice in the lesson, while working at the overhead projector, the author was actually faced away from the left hand side of the room and failed to see raised hands on that side.
- on two occasions, the transitions from one activity to another were less than effective.
- in general, the pace of the lesson was too fast, with the author being overly concerned with getting content covered.

The two mathematics colleagues felt that the revision work by the author on the concept of mapping was too abstract. The following suggestions were offered as an aid towards making the concept of mapping more applicable in future mathematics teaching:

1. Morse code is one example of mapping. Letters and numbers are mapped onto combinations of dots and dashes. These in turn can be transmitted as short and long flashes of light or pulses of electric current. At the receiving end, the dots and dashes are mapped back to letters and numbers.

11. The mapping of telephone subscribers onto their telephone numbers is another example. It stands in contrast to the more common mappings of points to points or numbers to numbers.

Stage 4 was complete when the author noted three areas for the future improvement of his teaching:

1. make abstract concepts more applicable to real-life situations
2. increase the level of awareness and vigilance while using the overhead projector
3. do not be overly concerned with getting content covered - pupil understanding is important.

A number of general comments and reactions were received on the process of using the video for peer appraisal:

1. It's good for improving communication and integration among mathematics teachers. With time it could lead to a stronger sense of unity. This is not the case at present - teachers tend to guard their teaching.

11. The video helped you (the author) to pay attention to things you were not previously aware of. It's like a coaching aid. It now becomes your responsibility to put the learning into practice.

111. It will take a long time before such a technique becomes a normal part of teacher's teaching. Equipment is too often associated with bother.

One teacher stressed the importance of establishing trust to ensure honest feedback and that not all teachers in the school would be open to receiving negative feedback:

It is difficult to expect colleagues to give negative feedback unless there is a climate of openness and trust among those engaging in the exercise - sensitivity is an important issue. We know each other but for other teachers I'm not so sure if it would work unless the 'trust' element is fostered first before meaningful analysis can take place.

The need to consider the process of video analysis as more than just 'armchair' viewing was highlighted by the remedial teacher:

Observation of a video demands an ability to define the problem in teacher performance and to analyze the data accurately. It also implies that teachers have the skills which enable them to give effective feedback.
The author would agree strongly with the latter comment. Teachers are trained in cognitive and learning skills; they do not necessarily have human problem-solving skills. These comments have implications for those whose task it will be to train teachers to meet the appraisal challenge.

On a personal note the author would add that the videotape of his mathematics class in conjunction with colleague feedback has helped him to observe objectively and more critically the performance of a past self. Relationships with colleagues were enhanced and a number of suggestions were made to improve his mathematics teaching. The hope and expectation is that such learning can be transferred to other situations in future mathematics lessons. However, a problematic area of concern is the extent to which such creative approaches as peer observation might become a routine feature of the professional practice of mathematics teachers and the extent to which they will take responsibility for rather than merely co-operate in the activity.

7.5 The inevitability of formal appraisal

Both self-appraisal and peer appraisal incorporate 'bottom-up' and 'sideways' elements to the appraisal process. In the U.K., the need for the formal appraisal of all teachers has found recognition in the development of a national teacher appraisal scheme which the Government intends to introduce over three or four years from September 1989 [181]. This 'top-down' element to the appraisal process has attempted to avoid the detrimental features normally associated with superlative type schemes. This move towards formal appraisal has not been confined to the secondary sector. Third-level institutions in the U.K. have recently taken up the challenge which this trend
has posed. Loughborough University of Technology, for example, has devised a detailed Staff Development and Appraisal Scheme which has been agreed for a two-year trial period from July 1988. The main purpose of the scheme is to foster development of individual members of staff and of the institution. A monitoring procedure is included with a review promised after two years. Noteworthy features of the scheme include the close link between formal appraisal and staff development and the current attempts to develop a role for students in the appraisal of academic staff [182].

This trend towards formal appraisal is likely to affect education policy in other countries especially Ireland. Formal appraisal appears to be inevitable and it is essential that mathematics teachers become involved in discussions to ensure that a credible national model evolves. Otherwise, at a time when commitment within education is at a low ebb, a formal appraisal system for mathematics teachers could lead to apprehension, fear and more stress. Unless it is perceived in a positive light, where the requirements to help and improve are made supreme, mathematics teachers will react negatively, and the potential of appraisal will be fragmented. The next chapter outlines the author’s proposal for a national model for the appraisal of secondary mathematics teachers in the Irish context.
CHAPTER 8

A MODEL FOR A NATIONAL SYSTEM OF APPRAISAL FOR SECONDARY MATHEMATICS TEACHERS IN IRELAND

8.1 Introduction

In this Chapter, the author attempts to customize formal appraisal for secondary mathematics teachers by interpreting and adapting the design of appraisal systems to meet specific requirements. A national model for the appraisal of secondary mathematics teachers is then presented integrating the insights generated to date from this thesis. Next, the author considers strategies for the successful implementation of the model. Finally, the idea and models which emerge from this Chapter are subjected to a limited amount of expert scrutiny by the author.

8.2 Contextual constraints

In Chapter 3 it was noted that the impact of Ministry of Education Inspectors on the quality of mathematical education through the monitoring process is virtually zero in Irish post-primary schools. The emphasis is firmly on supervision and control. There is little evidence of change in this regard and change is not likely to occur in the current economic climate except in the direction of increased control and accountability. Given these
circumstances which are hardly unique to Ireland, it is unlikely that self-appraisal and peer appraisal on their own would find official support as a viable alternative to formal appraisal although the proposition has merit and might find expression in other systems. As an essential stage in a full formal appraisal system for mathematics teachers which addresses the need for public accountability, self-appraisal and peer appraisal retain benefits for the system since the promise of involvement in these processes is one of personal growth and development for mathematics teachers leading to improved pedagogy. These considerations ought to have a direct influence on the way formal appraisal is implemented and the form that it takes.

The two-tier system (Ministry of Education and schools) of secondary education in Ireland, characterized by extreme centrality, represents an additional constraint. Although the author’s proposed model is an ideal one incorporating regional education structures, he acknowledges the limitations of the existing two-tier system by promulgating an interim model. Moreover, the author’s proposal for a national model for the formal appraisal of secondary mathematics teachers was confined to a consideration of developmental aspects and a limited evaluation. Lack of political will at national level thus constituted another contextual limitation.

8.3 Guidelines for an appraisal system for mathematics teachers

The author is mindful of the fact that formal appraisal schemes are designed for a purpose. The overriding consideration in this regard for secondary mathematics teachers must be to improve current performance by motivating these teachers towards better practices through self and professional development. The ultimate aim as
outlined in the introduction to Chapter 7 is to improve teacher effectiveness through improved performance in mathematics teaching. If appraisal is to be seen as a professional process, requiring skill, empathy and trust, then credibility must be an essential feature. The knowledge gained from Chapter 5 indicated a consensus on principles for successful appraisal schemes. These acknowledge teacher concerns and have been adapted here to meet the needs of secondary mathematics teachers.

General guidelines

(1) The main thrust of appraisal is positive, involving teacher commitment to continuous improvement in performance.

(11) Special consideration ought to be given to overcoming the natural (but fundamental) fears and suspicions that many mathematics teachers have of formal appraisal.

(111) Teachers are averse to hierarchical, superiote and dictatorial methods of appraisal. Appraisal of a joint problem-solving or 'open' approach, where teacher involvement is maximized can help promote acceptance of appraisal as a worthwhile process.

(IV) Operative appraisal schemes should be kept simple in nature.

(V) Without adequate resourcing appraisal will fail.

(V1) Appraisal should not focus solely on classroom performance. It should also include an evaluation of peer/collegial skills, leadership ability and the general contribution of the teacher to the school and community.

Mathematics related guidelines

(1) Appraisal must take cognizance of the pedagogical knowledge of mathematics teachers and research into effective mathematics teaching.

(11) Formal appraisal should be preceded and informed by the mathematics teacher engaging in a process of self-appraisal.
Classroom observation of the mathematics teacher is important.

In attempting to define teacher competencies, evaluative criteria are problematic. However, these should be jointly negotiated and agreed before the observation by the appraiser and mathematics teacher. This procedure accepts the importance and validity of an individual mathematics teacher's view of teaching.

Mathematics teachers should receive feedback as soon as possible after the observation. The quality of the post-observation discussion forms the cauldron to an effective system of formal appraisal. It should be positive and clear. Goal setting should be specific, realistic, challenging but achievable and growth facilitating for the teacher involved.

Staff development and training needs of mathematics teachers as identified by the appraisal process must be met by both the Ministry of Education and schools.

Management specific guidelines

Unless appraisal is linked to in-school management and evaluation it risks being rejected.

Appraisal must take context into consideration. This involves an appraisal of the aims, syllabus and resources within which the mathematics teacher works and an articulation of the constraints imposed on the teacher by colleagues and management.

Training is necessary for all partners involved in the appraisal process and this training should be school-based, experiential and involve the teacher in a participative role.

8.4 A model for the formal appraisal of mathematics teachers

The author has devised a model for a national system of appraisal for secondary mathematics teachers which addresses the need for public accountability and improved pedagogy in a model system for the Irish context. This model is elaborated in the following paragraphs. The aim is to iterate to an acceptable system by seeking expert
opinion in a structured way and applying it.

A three-tier system involving Ministry of Education Inspectors, Local Education Councils (LEC’s) and schools is proposed. Responsibility in LEC’s will be given to Chief Executive Officers (CEO’s) and specially trained Appraisal Officers (AO’s) who should be experienced teachers. Together with an Appeals Committee and a Monitoring Board, this will constitute the infrastructure for an appraisal system (see Figure 10). It is to be noted that the model provides a role for the pupil as consumer at school level and a participative role for parents as 'surrogate' consumer on the Monitoring Board. It is acknowledged that the proposed model is an 'ideal' one, as the LEC structure does not exist at present in the Irish post-primary education system although recent indications from the Irish Ministry of Education suggest otherwise [26]. In this connection, the need for an interim model is considered later in the Chapter.

8.5 The Logistics of Implementation

In the first instance, the process will be 'top-down', starting with the appraisal of the Headteacher. This will indicate the Head’s firm commitment to the scheme. This will be followed by the appraisal of the Head of the mathematics department and other senior staff in the department depending on the size of the department. This procedure will ensure that the Headteacher, the Head of the mathematics department and other senior staff within the Department who, under the logistics of the scheme to be described, will become appraisers will have been appraisees before they are appraisers. This will give them useful experience to bring to their subsequent role of appraiser. The 'bottom-up' and 'sideways' aspect to the appraisal model is evident at school level through self and peer appraisal. This will allow appraisees (the
Figure 10: A three-tier model for a national system of appraisal
mathematics teachers) to feed their objectives and action plans up through the system to influence departmental and school policy.

It is envisaged that headteachers will be appraised by a trained Appraisal Officer (AO) who has had recent experience in that position. The AO should consult with teachers in the school before arriving at an agreed report. In the case of mathematics teachers, self-appraisal ought to be on-going and continuous (this can include pupils' perceptions of the mathematics teacher). Full formal classroom observations will be conducted by the Headteacher or another senior teacher with experience chosen by the Headteacher e.g. a Head of Department. Mathematics teachers should also be strongly encouraged to engage in peer appraisal (to be chosen by the teacher), which could be used by the Head as additional data in the production of the final appraisal report. This final report should be agreed between appraiser and teacher and points of contention noted. Note that no distinction is made between probationary and experienced teachers and LEC or Department of Education induction procedures should be taken into account.

In the guidelines (Section 8.3), the need to avoid hierarchical or 'top-down' appraisal schemes was highlighted. The 'bottom-up' aspect of the model is illustrated in Figure 10 by the broken arrow. In the school context, in-school evaluation and review are perceived to be inseparable from the general appraisal process. Teacher involvement is thus maximized at school level and this avoids appraisal being viewed as an isolated activity. Notwithstanding this, levels of accountability are implied from each tier to the next. Firstly, the teacher is accountable to the Headteacher, who in turn is accountable to the C.E.O. of his L.E.C. via an Appraisal Officer. Finally, those involved in appraisal at L.E.C. level ought to be subject to scrutiny.
from Department of Education Inspectors. A functional model which portrays the two-way process of appraisal between the three levels is shown in Figure 11.

Realities in society must be considered when attempting to devise a national system of appraisal. The demands from each sector will be different and this could lead to competing aims, interests and pressures. Thus, it is unlikely that the perfect appraisal scheme will be developed. However, the interests of one particular group should not be allowed to predominate in an authoritarian fashion, to the neglect of other interested parties. This need to recognize social reality together with an awareness of the limitations of an appraisal system buttressed by summative evaluation were highlighted at the recent Manchester conference [120] on the monitoring and appraisal of advisory teachers for mathematics.

How often should formal classroom observations take place for mathematics teachers? If self-appraisal and peer appraisal by a colleague were on-going processes for mathematics teachers, two formal observations each year ought to be sufficient as a basis for a programme of professional development and external accountability.

Formal classroom observation of the mathematics teacher in the classroom can easily engender defensiveness and apprehension. However the central importance of classroom observation in the appraisal process is put cogently by Graham et al [114] (p.5). Most teaching and much learning takes place in classrooms, so, if the effectiveness of the teaching/learning process is to be appraised, classroom observation will offer the most practical procedure for collecting data about teacher performance. This important component of formal appraisal deserves further attention.
Figure 11: An operational model for a national system of appraisal
8.5.1 The formal observation cycle

The mathematics teacher should be in a position to negotiate a typical class lesson and time as this offers the possibility, in conjunction with the appraiser, of appraising some particular aspect of classroom performance. The following stages are suggested as a suitable format for formal classroom observations. The genesis of the following rationale was inspired by Rolph's [137] evaluative procedure, as cited in Selmes [134]. The author's adaptation includes the following stages:

- initial preparation
- classroom observation
- post observation dialogue and deliberation.

A. Initial preparation

(1) Self-evaluation forms

Initially, the mathematics teacher may benefit by using a self-evaluation form to help decide which aspects of classroom life and work he should focus on. This process, together with a suggested self-evaluation instrument, has been elaborated on in detail in Chapter 7. The subsequent reflection and analysis can help provide evidence for decision-making in the pre-observation discussion.

(11) Pre-observation discussion

During this stage, the mathematics teacher should be given the chance to comment on aspects of the self-appraisal instrument to help inform the discussion. Both participants will decide which aspects of their teaching will be evaluated and then identify the criteria/qualities to be evaluated. Prompt lists may be used as an aid in the elaboration of evaluative criteria but this may not be
necessary. What is necessary though is that the criteria should be mutually agreed upon beforehand, as this will form the essence of a simple evaluation sheet to be used by the appraiser.

B. Classroom observation

The appraiser will complete the constructed evaluation sheet taking detailed notes where necessary relating to the criteria under review. Selmes' [134] simple evaluation sheet has already been provided by the author in Chapter 7.

C. Post observation dialogue and deliberation

As soon as conveniently possible after the observation, the mathematics teacher should first be asked to articulate his thoughts in relation to the performance criteria agreed upon. The appraiser can then give his feedback, making reference to any transcript notes if taken. Reasons for differing perceptions should be expressed and negotiated, with points of contention noted. Participants should avoid being judgmental about the observed teaching, concentrating instead on asking questions about whether similar or different teaching strategies might be used again. Thus, the teacher should be encouraged to make generalizations which will transfer to future teaching. In this manner, changes which could improve the quality of mathematics education to pupils should be made explicit and the positive role that self and peer appraisal could play in this future planning outlined. A summary document should be agreed upon and where necessary points of difference written in. Any goal-setting exercise ought to be positive, challenging and growth facilitating for the mathematics teacher. Taken together, these three stages can be repeated to form a spiral process.
8.5.2 Monitoring procedures

Concerns about the possible quality of some appraisal is understandable, even by those teachers who might agree with appraisal in principle. These can be minimized if the appraisal system is monitored and the right to appeal built in. With regard to the monitoring aspect, responsibility for reliability, validity and fairness of the operation of the system should reside with a Monitoring Board, comprised of representatives from the Teaching Body, LEC's and Ministry of Education Inspectors. New up-to-date guidelines would also be issued by this Board when necessary.

A. Appeals

In the post-observation discussion, the teacher is presented with an opportunity to register differences of opinion. If it is deemed appropriate and beneficial, the mathematics teacher should be entitled to another appraisal from an Appraisal Officer (at the discretion of the Appeals Committee). Where mathematics teachers are found to be experiencing performance difficulty (major as opposed to the self-rectifiable type), appropriate support in the form of in-service training, guidance or counselling should be provided and accepted by the mathematics teacher. If, after a subsequent appraisal, an appropriate response is not elicited, then dismissal should not be ruled out. At any rate, the Appeals Committee will arbitrate on such grievances.

B. Record keeping

Each teacher should receive a copy of the summary
appraisal report and the Headteacher should retain similar copies on all staff members which should remain confidential. The C.E.O. should also have access to teacher appraisal reports. Ministry of Education Inspectors ought also to be in a position to view these reports at their discretion. Likewise, Headteachers should receive a copy of their own appraisal report and copies furnished to the C.E.O and Ministry of Education in confidence. The role which such reports might have in career development is open to discussion.

8.6 Strategies for the national system of appraisal

To be successful, any appraisal model must consider carefully relevant and appropriate strategies. These are considered in three stages for ease and coherence:

- initial formulation and design
- implementation
- evaluation.

8.6.1 Formulation and Design strategies

At this stage, it would seem imperative that in order to harness the necessary commitment and sense of ownership for the appraisal process, all partners must be involved in initial formulation and design of the appraisal scheme. This implies support for normative re-educative strategies of change [159]. The participative role of teachers in the process has been highlighted effectively making teachers 'shareholders' in the initiative. This bottom-up approach should help surmount 'teething' problems and help promote effective implementation as change is often accompanied by early set-backs and suspicions.

The approach advocated by the author implies full and adequate consultation with the appropriate interest groups from the outset. This would include taking cognizance of
existing contractual relationships and relevant agreements between teacher unions and their employers. The absence of such consultative procedures can lead to a defensive attitude by teacher unions like the response (see Appendix I) from one teachers' union in the North-Eastern part of Northern Ireland in 1986 following an attempt to introduce ad-hoc appraisal schemes in some primary schools.

Formulation guidelines ought to utilize knowledge gained from a comparative study of appraisal schemes to help schools, teachers and appraisers. Mathematics teachers for example, must be absolutely clear with regard to their role in the appraisal process and as to the purpose(s) of the appraisal scheme. With regard to purposes, the danger of having too many conflicting aims has been pointed-out as one difficulty in attaining successful appraisal [174]. A plethora of aims cannot be achieved and some like merit pay, payment by results or the implicit monitoring purpose behind the recent introduction of pupil testing schemes in the U.K. risk outright rejection.

8.6.2 Strategies for implementation

If appraisal schemes are to evolve, pilot schemes ought to be considered and lessons heeded in the promulgation of appraisal on a national basis. Necessary manuals and guidance details need to be written concisely and couched in a language that teachers will understand. The Suffolk pilot scheme literature [165] presents a useful reference guide in this respect. In avoiding a 'top-down' power-coercive strategy, the national model and guidelines should allow for as much negotiation at local level as
deemed appropriate. Educational administrators and headteachers can contribute to the more successful introduction of the national model by considering insights from management education including the concept of planned educational change and the large body of empirical evidence on models of change processes.

To ensure that the benefits which can accrue from participation in appraisal are realized, the need for national and LEC commitment in the areas of training and development is of paramount importance. Hence, in asking mathematics teachers to desert the familiar for the unknown, it is incumbent that all partners in the appraisal process be professionally trained for the effective introduction of a national appraisal system. Training in the post-observation discussion component of the appraisal cycle for Heads, Appraisal Officers and mathematics teachers deserves particular attention if quality appraisal is to be effected. It is unlikely that the skills to be acquired can be learned other than through a coherent process of training involving the use of practice interviews on closed circuit television, role-playing and other similar techniques. Educational videos ought to be produced which show appraisal interviews being effected by senior appraisers and appraisees incorporating the principles of appraisal outlined earlier. This process of seeing appraisal in action and working in reality can help to increase confidence and surmount the natural fears and suspicions which many apprehensive teachers hold. The implication of the introduction of teacher appraisal into any school is that the appraisers will be trained in this way. Thus dissemination of the essence of the stages of the formal observation cycle by experiential methods appears essential to ensure that the process is adequately internalized.

However, a central problem is that relatively little is known about the way people, especially adults, learn and
change. Current theories that exist in relation to how adults respond to and learn from change and in-service training activities point towards a developmental model. Recent research by Crandall [183], for example, reiterates the power of peer group influence on adult learning while Smyth [127] argues that teachers learn about the concrete experiences and struggles of others by establishing collaborative partnerships with colleagues. In order for such teacher collaboration to occur, an active administrative commitment is required from the school principal and senior staff. This will facilitate the mobilization of individual mathematics teachers' energies for action and assist in the difficult task of winning people's hearts and minds. The latter comments point towards the significance of the Headteacher's role in attaining successful appraisal at school level.

It is the author's opinion that too little attention has been devoted to the significance of the Headteacher's role and indeed to an examination of serviceable strategies for the implementation of appraisal at school level. The failure of many innovations has been ascribed to the neglect of strategies at classroom level [184]. Since any attempt to introduce a national system of appraisal is itself in the category of innovation, a neglect of strategies at these levels can result in discontinuation of the new appraisal procedures and behaviour and a reversal to formal patterns.

Reverting to the metaphorical language used earlier in the Chapter, the Appraisal Tree will not have a chance to put down roots. Three key variables - lack of support and encouragement from the principal, lack of understanding and support from staff colleagues and lack of provision for professional development - have been shown to be associated with unsuccessful innovations at school level [184]. As appraisal is perceived to be a process and not an event certain attributes will be demanded from
Headteachers if appraisal is to become a normal and successful tool both for individual teachers and the school as a unit. These include the abilities to understand and empathize with teachers' values and attitudes, to develop and encourage their capacity for self-appraisal and self-reliance and to establish collaborative relationships with and between staff - relationships which portray openness, trust and credibility. He needs to ensure that teacher appraisal is linked to an in-school evaluation and review procedures to help promote coherence. In this connection, staff development and training needs as revealed by the appraisal process need to be linked to the more general process of fostering the school's capacity for growth and self-renewal.

Thus, appraisal ought to be linked to the more significant and fundamental process of whole-school staff development. This view of headteacher as a person assisting and empowering the mathematics teacher to reflect and improve on his performance stands in contrast to the superiote idea of a headteacher 'working on' and controlling teachers. In short, his knowledge of and his ability to apply insights and ideas from education management are necessary preconditions for the successful implementation of appraisal at school level. Earlier in this thesis, the lack of adequate education management courses for educational administrators, school principals and middle management in Irish secondary schools was perceived to be a serious drawback in the context of school organization and effective pupil learning. Compulsory courses in education management are required for all principals and senior staff immediately if appraisal is to succeed. In this connection, schools could employ the services of the recently formed Marino Curriculum Centre in Dublin to increase knowledge of management education, planned educational change and to promote an awareness of the significance of the concept of whole-school staff
development. Thus, it is fair to say that effective appraisal schemes must be accompanied at school level by equally effective policies in the areas of organizational change and staff development. The implications for national education policy in such areas as pre-service and in-service education and management education are of enormous proportions.

The major additional requirement is time. Time is required for mathematics teachers and appraisers to carry out the observations and discussions effectively. Time is also required for the mathematics teacher to absorb and respond to the consequence of the appraisal experience. Videos of capable, 'good' and effective mathematics teachers (as revealed by official appraisal reports) need to be produced and made available as an additional resource for self-study by those mathematics teachers who have been identified as in need of support and help. The private observation of these videos at a time chosen by the mathematics teacher helps to keep the identified 'weaknesses' confidential to the appraisee. Videos of 'poor' mathematics teachers might also be useful to illustrate how not to teach.

Appraisal is also likely to lead to demands for bringing in specialist advisory help and for visits to other schools to see experienced mathematics teachers teaching particular topics or using a particular teaching method etc. In this connection also, a new emphasis on increased collaboration and co-operation between schools in the area of reciprocal peer appraisal can help allay psychological fears which mathematics teachers may have of revealing and exposing their 'weaknesses' within their own schools. All these demands on time for teacher release will have obvious and profound implications for the school time-table as this will necessitate time for teachers to
meet, discuss, research and disseminate information on 'best' practice. In their absence, teachers may well perceive appraisal as having low priority and little status and difficulties cannot be worked through in a professional manner. Once again, thoughtful management has a role here in and between schools. Likewise, the L.E.C. can play its part by being generous in its allocation of time.

Despite the prevailing economic climate, adequate resources must be made available to implement these strategies. This includes finance to follow up identified developmental and/or remediation needs. Without them, the skills, empathy and sensitivity required to produce a credible appraisal system will be replaced by hostility, cynicism and a dejected teaching body. Above all, whatever system is adopted, it must not be brought in as an extra burden on the mathematics teacher. Changes must always be within the capabilities of the teachers in post.

8.6.3 Strategies for evaluation

The infrastructure and monitoring procedures necessary for an effective evaluation scheme have already been highlighted at system level. However, at school level, there is a need to establish a mechanism whereby both teachers and schools are able to learn from successes and failures. This procedure could involve regular review involving the posing of searching questions. The review process will help prevent stagnation. It could serve the useful purpose of examining alternatives and, if necessary, helping the reformulation of a new design for the appraisal model by a simple feedback mechanism. Essentially, this is a management function involving dialogue, awareness, decision-making and problem-solving skills. The need for such a mechanism places an onus on principals to develop effective patterns of communication.
and feedback to help staff cope with stress, anxiety or other problems associated with the implementation of an appraisal system. This view implies support for Goodlad's [185] perception of the school as an organic unit for change, thus emphasizing its development as a 'self-renewing' institution.

At least two staff meetings per annum ought to be set aside for the on-going review process. Earlier in this thesis, it was articulated that staff meetings, in general, are highly unproductive in the sense that they are impersonal, business-like, information giving and fail to exploit the growing potential of staffs as a group. Staff meetings, with appraisal review as the agenda, offer an opportunity to remove this impasse, provided that they are honest, personal and where the main emphasis is on pooling ideas and sharing problems and expertise alike. Leadership, communication and group dynamic skills are necessary for meetings to work in this way. Thus, the main emphasis for staff meetings (at least those set aside specifically for appraisal review) ought to be on the renewal of personnel, which can be an empowering, enjoyable and uplifting process, rather than a routine forum to meet the administrative needs of the institution. It is argued that appraisal review, conducted in such a collegial and professional atmosphere, will probably be more productive and effective than if carried out under the normal vertical stereotype model. Against this however, unless managed carefully, the collegial discussion and appraisal activities as envisaged in the author's operational model of appraisal (Figure 11) may well generate new roles and relationships not necessarily in harmony with the traditional linear management model typical of Irish post-primary schools.
Thus, if teacher appraisal is to succeed and evolve over a period of time, the implication is that there is a need for a school organization structure and management skills that will support it. If these requirements are met there is a strong case to be made for the 'thinking' or 'creative' school as a strategy for the continual monitoring of appraisal schemes at school level. There is a consequent obligation on the Local Education Councils and the Ministry of Education to devise a suitable mechanism to receive and channel this feedback towards the improvement of appraisal schemes at national level. These comments seem to reiterate the need for the provision of management development programmes for Headteachers in secondary schools. These management developmental programmes ought not to be confined solely to Headteachers. Senior staff especially Heads of Departments should also benefit from such courses as they, in conjunction with the Headteachers, will play a key role in the introduction, co-ordination and review of school appraisal schemes.

Appraisal review for small rural schools presents particular problems in terms of isolation and a lack of a common goal. However, various arrangements could be made in these schools to cluster schemes so as to share the benefits that accrue from appraisal along with fostering collaboration. The end result should mean that appraisal schemes will evolve and modifications made from the evidence which emerges. This should help match intentions and actions more closely. It would be an undersight if this mechanism did not also monitor the unintended as well the intended effects.
8.7 Evaluation

In keeping with the eclectic and illuminative nature of the methodology employed in the thesis to date, an attempt was made by the author to validate the ideas and models which this Chapter has generated. To this end, the author sought expert opinion from educators identified with certain constituency interests in education as follows:

- Ministry Inspectors (mathematics) (2)
- Chief Executive Officers (2)
- Secondary School Principals (4)
- Secondary mathematics teachers (4)
- Friendly academics (5).

The number of secondary mathematics inspectors for the entire country is very small, less than five. Chief Executive Officers are entrusted with the administration of Vocational Education provision in administrative districts which are similar to Local Education Authorities (LEA's) in the U.K. but on a much smaller scale. These districts are being rationalized from thirty eight to twenty two [26]. The school principals and mathematics teachers are representative of the four main types of post-primary schools and the sample was chosen at random with a geographical dispersion. The friendly academics include lecturers in University Colleges and Colleges of Education specifically concerned with mathematical education.

These 'experts' were invited in a cover letter to participate in a two-stage process which involved reading a specially prepared synopsis of the author's work and responding to a questionnaire (Appendix J). The questionnaire comprised sixteen questions with boxes to be ticked with three opportunities to elaborate and/or comment. The questions concentrated on appraisal, the self-evaluation instrument and the model for a national system of appraisal.
All of those invited returned the completed questionnaires except one inspector. The author was struck by the attention given to the task by the respondents as evidenced in their replies. All of the respondents valued the concept of appraisal in general. Fourteen stated that they operated appraisal formally or informally in their own roles. This included the four mathematics teachers who replied. All except one respondent agreed that the primary purpose of appraisal ought to be developmental. In this connection, one principal placed considerable emphasis on the need to link appraisal to whole-school review and staff development:

A major purpose of appraisal ought to be its help in evaluating and refining school policy especially in the area of staff development.

Twelve respondents agreed that it was necessary to set up a national system of appraisal for teachers. Interestingly there was unanimous support for a national system by those at the 'coal-face' namely, the mathematics teachers, principals and CEO's. The majority however, identified deficiencies in the proposed national model in its present form and questioned its viability on these grounds. Three respondents, for example, expressed a genuine fear that the proposed LEC's would resemble the current VEC structures which according to one respondent was 'riddled with politics'.

Additional issues and concerns which emerged included the possible overly bureaucratic nature of the model, the inability of Ministry inspectors to engage in productive appraisal, the problematic role of teacher unions and the need for a Teachers' Council. One of the friendly academics perceived the model as having too many links in the information/communication chain which could encourage mechanistic reporting. Emotive comments were elicited from three mathematics teachers on the issue of parental
participation on the Monitoring Board. One suggested that parents might engage in a 'witch-hunt' in certain circumstances while another felt that the involvement of 'non-professionals' could be used to intimidate rather than help. While it would be inappropriate to generalize from the limited sample, such comments serve to focus attention on the natural psychological fears and suspicions which mathematics teachers have of appraisal. All of these issues require careful attention and planned strategies for the successful implementation of the national model. Upon close examination it is fair to say that many of the difficulties identified relate to existing circumstances and not to the proposed scenario under LEC's as conceived by the author.

Notwithstanding this, the proposed model is an ideal one based on the assumption that the concept of regionalization of education structures is both desirable and inevitable in the near future [26]. The absence of a local authority structure in the Irish context was pointed out by a number of respondents. This has prompted the author to search for an interim model until such time that LEC's or a similar framework is instituted in the Irish post-primary education system. The author proposes that the LEC structure could be replaced in the interim by an informal education council existing at local level comprising a wide range of constituency interests including principals, teachers, the CEO of the VEC (who could act as Chairman) and parent representatives. This arrangement would serve to retain the significant advantages of local involvement, local autonomy and allow regional differences and action plans to be fed up through the system to influence national policy. Essentially, what is required is an informal structure which allows the aforementioned parties to meet, plan and discuss regularly at local level in order for the national model to become operational. The proposed new twenty-two administrative districts [26] could provide boundary regions for the
interim informal education council as could existing Health Board or Regional Development boundaries.

There was unanimous support among the experts for self-appraisal and almost unanimous agreement that the self-appraisal instrument as presented was beneficial. The mathematics teachers in particular perceived the instrument as helpful. The majority agreed that it was about right in length with two people suggesting the use of section headings as a check-list. No one disagreed with the emphasis in the instrument.

As regards the process of appraisal, there was general agreement on who should be involved, the purpose of appraisal, the stages involved, the need for a gradual/experimentalist approach and the training needs including in-service training for teachers. One mathematics teacher indicated a preference for video appraisal as opposed to classroom observation to avoid exposure of performance difficulties. Two other mathematics teachers expressed a desire for groups of mathematics teachers to meet and participate in the development of evaluative criteria. In this connection, it was recommended that a National Advisory Body on the Teaching of Mathematics be established to help co-ordinate the task facing mathematics teachers which the appraisal challenge poses. Those involved at administrative level (CEO's, Principals and Ministry Inspectors) drew attention to the implications of national appraisal in terms of time, finance and resources. However, one CEO felt strongly that such expenditure would be well justified as 'appraisal is vital to the development of Irish education.' There was almost unanimous agreement that current Irish educational structures do not facilitate the introduction of a national appraisal scheme. This poses major implications for Irish educational administrators and the Ministry of Education; certainly a reversal is needed from the current emphasis on control and
supervision.

Finally, a recommendation from one of the friendly academics deserves attention, if only for its futuristic orientation. It relates to a suggestion for the extension of a self-evaluation instrument in the form of a 'computer expert' system (to be developed) which would help mathematics teachers diagnose problems 'in a friendly but anonymous fashion':

This could afford an opportunity to become more quantitative but without the crudeness of sample statistics, giving assessments in probabilistic terms. It could also produce check-lists more tailored to individual needs. This could be done on a national scale if that is not too 'Big Brotherish'.

The author is heartened by the responses elicited and the insights and recommendations gained. The key elements in his approach have been accepted as such and valued by the respondents.

This Chapter has outlined the author's proposal for a national model for the formal appraisal of secondary mathematics teachers in the Irish context. It attempted to address the need for public accountability and improved pedagogy in a model system. An interim model was also presented because of existing contextual limitations. Moreover, the author's proposed national model was confined to a consideration of developmental aspects and a limited evaluation. It is unlikely that a major formal evaluation could be achieved unless there exists the political will to do so.
CHAPTER 9

A CASE FOR THE SELF-EMPOWERED MATHEMATICS TEACHER

9.1 Introduction

In Chapter 3 of this thesis, the author was concerned about the professional situation of Irish secondary mathematics teachers:

Even today, there is a pressing need for a process designed to help mathematics teachers adopt a new professional perspective, to regain control, to restore their decision-making capabilities and to equip them with a belief in their own autonomy.

Evidence from Chapter 2 supports this analysis which indicated that in the past, mathematics teachers were confined to the implemented mathematics curriculum. This Chapter takes the alternative view that mathematics teachers should not merely be concerned with implementing changes which are decided upon by outside agencies but rather that they be the prime movers and masters of the process. To this end, a case is made for the self-empowered mathematics teacher who, it is argued, has the capacity to subject his own working context to scrutiny and to consider mathematics teaching and how to teach problematic. In the process, mathematics teachers will be better able to assist curriculum developers in improving mathematical education by formulating designs and demands.
To this end, the author describes his proposal for, and reaction to, an alternative differentiation strategy for Junior cycle mathematics.

Initially, the general notion of empowerment is considered in the context of the depowering position in Ireland. A case is then made for self-empowerment as an intervention strategy in secondary mathematics education. An important synthesis between appraisal and empowerment is then elaborated. This latter connection culminates in the presentation of a model which is offered as a strategy towards the improvement of secondary mathematical education. The Chapter concludes by considering some outcomes and implications of the proposed model.

9.2 The concept of self-empowerment

9.2.1 The process of self-empowerment

Self-empowerment is a process involving people in deepening their awareness of the factors which shape their lives, in critically analyzing problems which confront them and in eliciting the most appropriate responses to deal with these problems, using a wide range of information (including their own values) on the choices available and their consequences. Self-empowerment, in examining the constraints on making decisions also seeks to equip people with necessary skills, not alone to make and implement informed choices despite pressures and constraints but to set about, if necessary, adapting and changing the disabling or depowering system. In this connection, Vanderslice [186] comments:
The combination of a stronger positive self-concept and the skills and knowledge to deal more effectively with one's environment increase a person's sense of being able to have some control over that environment and thus to act accordingly. (The author's italics)

In short, it is a process by which people acquire knowledge of themselves and their environment. This, along with the development of skills can result in more self-managing and self-confident individuals, who are in control of their environment and thus able to promote change which is growth-facilitating. A primary aim then is to assist individuals to take greater charge of themselves and their lives. Keith Tones [187] notes:

Self-empowerment is a process designed to restore decision-making capabilities and to equip individuals with a belief in their autonomy, together with the skills necessary to enable them to decide what to do about their own situation.

Self-empowerment is thus concerned initially not so much with information about the external world but rather new information about the internal world - expanded self-awareness, self-understanding and self-control. Many of the personal and professional actions of teachers are based on their individual commitment to, and internalizing of, behavioural norms of which they are unconscious. An analogy of this reality, albeit a dramatic one, is to be found in the world of Freud. His objective was collaboration with patients in an attempt to raise consciousness and re-educate to help facilitate a change of attitudes.

9.2.2 The depowering position in Ireland

It is easy to underestimate the depowering and disabling
effects which the current educational system is exerting on Irish secondary mathematics teachers. The introduction to this chapter referred to the loss of control by mathematics teachers in their teaching context and one writer [188] has described Irish teachers as powerless functionaries. The unsatisfactory position was elaborated in Chapter 3. In the present context, it is appropriate to summarize the major limiting factors which have stood in the way and prevented Irish secondary mathematics teachers from adopting a professional perspective to their work:

- the failure to provide relevant, interesting and exciting mathematics curricula for the majority of pupils
- a mathematics curriculum in which the relevance and applications value of mathematics is not being taught
- no mathematical curriculum development projects (with one exception) at national, local or school level
- few teachers' centres and none specifically catering for mathematics
- no mathematical advisers for teachers on a regular basis
- the lack of a proper promotional and career structure
- the absence of a Teachers' Council which would assume responsibility for the maintenance of professional standards
- pre-service training of mathematics teachers in general emphasizes the specialist knowledge aspect of the subject as opposed to professional processes such as self-reflection and collegiality
- in-service training is infrequent, voluntary and haphazard; courses which do take place tend to neglect the professional skills and processes necessary to teach mathematics effectively in the classroom
- a lack of opportunities for mathematics teachers to add to their formal qualifications by attending
diploma or certificate courses in mathematical education
- no formalized concept of a mathematics department
- a piecemeal approach to information technology including a lack of knowledge of the potential of microcomputers to enhance effective mathematics teaching
- the lack of consultation and participation in educational policy and decision-making at national, local and school level
- the existence in general of hierarchical authority structures in schools which fail to promote teacher participation in curricular issues; passivity, acquiescence and maintenance of the status quo are the order of the day.

Upon closer examination, the aforementioned factors are either contextual or embedded in the taken-for-granted practice of mathematics teachers. What are the effects of the situational analysis described above? Such an insular system models unprofessional behaviour, discourages innovation and entrepreneurial skills and provides little opportunity for the mathematics teacher to gain a measure of control over his teaching. The low level of management education in Irish secondary schools has been a serious drawback in allowing in-school support structures to develop which might enhance the professionality of the mathematics teacher. Irish Headteachers have failed in their responsibility to provide opportunities for thinking about teaching and a coherent context in which change can take place.

The majority of Irish secondary mathematics teachers are thus realizing only a fraction of the potential which lies within them. In Hoyle's [81] terms, mathematics teachers adopt a 'restricted professionality'. Inadequate time for reflection, combined with traditional routines and teacher isolation has led to an inactive approach and low morale
among mathematics teachers. Furthermore, mathematics teachers are expected to be conscious of the future for which they are preparing their pupils and whose lives will be influenced by such issues as:

- fewer jobs
- changing ideas about work, jobs and careers
- a need for lifelong education and re-education
- a need for greater self-reliance, adaptability and flexibility
- rapid pace of change attributable to the information revolution.

Currently, secondary mathematics teachers do not model competencies and skills which their pupils can take with them into their own lives when they leave school. As noted already, a primary reason for this is the fact that their own model exhibits inactive and reactive features rather than a proactive orientation. The curriculum is of central importance to the professional work of mathematics teachers. The curriculum must be planned, implemented and assessed. The early chapters of this thesis have clearly indicated that mathematics teachers have, in the past, been confined largely to the implemented curriculum. The resultant scenario is one in which mathematics teachers are faced with imposed decisions and are expected to cope with practice and new modifications in the best possible way. Educational planning appears to be erratic and does not enshrine the fundamental principle that educational planning is planning an education worth having. The ultimate effect is that mathematics teachers are not in a position to develop their capacity for self-determination. Clearly, there is a need for an alternative outlook and ideology, a new strategy. A primary goal must be to help mathematics teachers acquire the necessary knowledge (in terms of expanded self-awareness, self-understanding and self-control) on which to base an informed assessment of the present in the light of development towards future
requirements.

How can mathematics teachers be helped to take increased control of their professional lives? Undoubtedly, such attributes as commitment, initiative and willingness to innovate are necessary but not sufficient. The effort to challenge one’s own and other’s accepted practice, norms, assumptions must originate in a liberation of one’s own understandings, one’s grasp of what is possible. Thus, a critical characteristic of any proposed strategy is the degree to which it ‘reorients, focuses and energizes participants towards knowing reality in order to transform it’ [189]. It is argued then that some process is required to liberate mathematics teachers to give them a belief in their own autonomy, so that they can possess the power to participate in decisions that affect their lives; the power to be self-directing; the power to adapt, survive and grow in a changing world, the power to learn; the power to teach; the power to help colleagues in a co-operative fashion. In this connection, the process of self-empowerment appears to have the potential to raise the consciousness of mathematics teachers to what the system is doing to them in terms of teacher control.

9.3 Self-empowerment as an intervention strategy in secondary mathematics education

The empowerment strategy seeks to assist mathematics teachers to overcome the restraints on their power to act effectively; to invest mathematics teachers with a capacity to re-appraise their own thinking about their practice and about the ideological and institutional context of their work. In this way, improvements in the professional development of mathematics teachers will lead to enhanced pedagogy and an improved quality of mathematical education to pupils. Empowerment aims to
place the perspectives of mathematics teachers at the heart of decision-making. It accepts that their concerns are the really important ones on matters such as classroom teaching, the practicalities of their work context, the possible benefits to their pupils and to their teaching, the balance of gain and cost to the mathematics teacher. This is to reverse the secondary status currently given to the perceptions of mathematics teachers and the value of their pedagogical knowledge.

The introduction of such a process as empowerment implies an active administrative commitment from the Irish Ministry of Education and schools. Initially, workshops of an experiential nature would be required to make mathematics teachers aware of the potential of empowerment. The next stage involves helping mathematics teachers translate guiding principles into specific operational procedures. This process requires trained facilitators who will help mathematics teachers search for meaning in their practice and develop a deeper understanding and purposefulness in their work by improving action-research skills. These facilitators could take the form of the mathematical advisers recommended in Chapter 3. Alternatively, school principals could be trained, who in turn would meet with mathematics teachers as a group and disseminate the essence of the empowerment notion. In addition, he ought to encourage the group to reflect, to suggest agendas, to introduce and evaluate experimental programmes and to become self-sufficient.

Although the initial empowerment process begins with individuals, mathematics teachers can and should seek to empower others. This is a creative process where empowered mathematics teachers can act co-operatively with others who share a similar reality and begin to change the features of their environment in which they work. With the inclusion of the support element mentioned above, the
extended and creative process of empowerment is shown in Figure 12.

Attention is now turned from the theoretical and conceptual base of empowerment to a consideration of its merit for secondary mathematics education. Earlier in the thesis (Chapter 3), the author articulated the view that immediate attention ought to be given to the task of reappraising the place and aims of mathematics in Irish post-primary education by addressing such fundamental questions as "why teach mathematics at all?", "how does mathematics relate to general educational goals?", or "what is the place and aims of mathematics in a technological society?". It was suggested that responses to these and other important questions facilitate the justification of the place and aims of mathematics in secondary schools. In conjunction with mathematical advisers, groups of mathematics teachers who share the empowerment ideal can help to render such a key issue problematic and in the creative process of deliberation, experimentation, and evaluation, mathematics teachers can generate a comprehensive and defensible set of mathematical aims for the Irish context. Such areas of concern as the 'drop-out' problem, the 'alignment' problem or the 'profit-pleasure' imbalance can be subjected to examination and alternatives proposed for consideration at national level.

In Chapter 3, the author stated that the restructuring of the mathematics curriculum is an urgent problem facing mathematics educators and teachers in Ireland. The 'compulsory' mathematics curriculum, based on a linear model, has not served the needs of the majority of secondary pupils. Recent modifications at Junior cycle have been dominated by a 'content' view of mathematics and constitutes an inadequate response. One alternative proposed by the author was a restructuring of the mathematics curriculum on the basis of applications of
Empowered mathematics teachers

Support from Ministry of Education and School

The initiation of creative and responsible changes in school environment and teaching/learning context

Collaborative work with other empowered mathematics teachers involving deliberation, experimentation and evaluation

Figure 12: The creative process of empowerment
mathematics by:

(1) more links between various mathematics topics
(11) more links with other subjects
(111) project work with an emphasis on mathematical modelling.

Through the process of deliberation, experimentation and evaluation, empowered groups of mathematics teachers can subject such a proposition to criticism and plan ways of testing the alternative including the need to arrive at serviceable strategies in order for the new alternative to reach classrooms in a worthwhile form. By so doing, a more fundamental analysis can be achieved, one which deliberates on the pedagogical purpose and justification of the various types of applications as outlined by the author in Chapter 3.

The logic behind the current compartmentalised mathematics curriculum is flawed and has given rise to severe limitations on mathematical learning for the majority of post-primary pupils. The resultant emphasis on examination teaching has concentrated upon the learner's acquisition of techniques and routine procedures. Through the empowering potential of planning, processing and evaluation (or action-research) secondary mathematics teachers can help in the development of new assessment procedures which extends the range of 'assessable' knowledge so as to cover all the various types of mathematical knowledge including 'how to' apply mathematics, 'how to' generalize and justify. This process can help initiate a radical overhaul of the presently flawed system including the distorting influence of the universities and examinations on the mathematics curriculum and teaching. Such an overhaul will help shift the emphasis from exam performance to overall ability and achievement.
With the exponential increase in information and its easy availability from a variety of sources outside school, a key concept must be the need for mathematics teachers to shift the emphasis from the mere accumulation of facts to the development of actual skills and processes. The concept of empowerment has the potential to make this important goal attainable. Indeed the role of mathematics in a technological society permeated much of the analysis with regard to the discussion on key mathematical issues earlier in this thesis. It was stated that the debate on the role of the new technology vis-a-vis the mathematics curriculum and effective mathematics teaching needed fundamental reappraisal together with strategies for implementation at classroom level. To this end, groups of self-empowered mathematics teachers have the capacity to propose, implement and evaluate action plans which incorporate elements of the new technology. For example, the experiences of mathematics teachers who attempt to integrate calculators successfully into their teaching can be evaluated with a view to an improved pedagogy. In relation to microcomputers, the notion of empowerment allows mathematics teachers to disseminate information on how best to apply the inductive paradigm (compute-conjecture-prove) in the teaching context or on benefits to be gained from using algorithms.

The potential of empowerment is increased if the concept gains the co-operation of secondary schools with insights and experiences being exchanged on an inter-school basis. In this connection, data bases could be established to help disseminate information on best practice. The experiences of deliberating and experimenting on curricular alternatives and on other key issues as suggested above will help mathematics teachers to become autonomous agents in the practical business of curriculum development. It will help provide opportunities for mathematics teachers to exercise their proactive qualities and practise the skills called upon in curricular change:
analyzing, evaluating, justifying, planning, experimenting, implementing, reviewing. Ultimately, this process can assist curriculum developers and mathematics teachers to plan, reinforce and unite mathematical learning experiences and to embed them within a mathematical framework which students can appreciate and utilize.

In short, the concept of empowerment represents a strategy for enhancing the professional development of mathematics teachers through the action-research cycle and in turn helps promote their adaptability and flexibility. Finally, the concept of empowered mathematics teachers in task-directed groups is novel and has excellent potential.

In Chapter 3, the author also drew attention to the potential of the 'modular' curriculum as an alternative to the existing 'content' orientated approach for Junior cycle mathematics. Empowerment implies that this proposition ought to be subjected to scrutiny and an evaluation made of its viability. This task is attempted by the author in the next section.

9.4 An example of a practical alternative strategy for Junior cycle mathematics

Designing relevant mathematics courses at Junior cycle which meet the needs of all pupils, especially those to be found at both extremes of the ability range, provides a great challenge to programme developers in secondary mathematics education.

The recently revised mathematics syllabuses at Junior cycle now offers mathematics at three levels - A, B and C - where level A is intended for the more able pupils. This revision is based on a content orientated approach
where syllabus C - intended for the less able pupils - is a ‘watered-down’ version of that offered to their more able counterparts at levels A and B.

As an alternative strategy for differentiation at Junior cycle, the author proposes a modular based mathematics curriculum which incorporates a 'core plus options' feature. It is proposed that all pupils would take a common core which would constitute up to seventy per cent of their total programme in mathematics. The remainder of the time will be given to the provision of modules or short courses designed to meet different ability ranges.

In relation to the common 'core', it is possible to present this in different ways and at different depths. Moreover, the common course should be based on an agreed list of 'essential' mathematical competencies bearing in mind the distinct needs of those who enter vocational training and those who proceed to further education. A suggested and non-exhaustive list of 'essential' mathematics is given below. Caution is needed to ensure that such a list is not limited to competency in computational skills only or the curriculum will become mathematically unbalanced.

When considering the module options, it is both possible and desirable that some of the short courses be embodied in individualized material presented by a variety of media including the use of microcomputers. Finally, the author has grounded his modular approach on a new set of mathematical aims and it is hoped that the proposed structure illuminates these where possible.

A. A proposed set of mathematical aims at Junior cycle

(1) To help pupils develop a critical attitude to numerical information presented to them in this information age.
(2) To help pupils develop an appreciation of the creative and aesthetic aspects of mathematics and in particular to help them appreciate the power which mathematical knowledge and understanding can give them in the solution of their own problems and decision-making.

(3) To encourage all pupils to develop the ability to 'mathematize' by the provision of appropriate experiences. Such processes would include classifying, comparing, ordering, abstracting, symbolizing and generalizing.

(4) To develop a positive attitude towards mathematics as an interesting and worthwhile subject with particular emphasis on applications.

(5) To encourage a well ordered and gradual transition from the more practical work of primary school mathematics.

(6) To ensure that mathematics reflects and contributes to the Irish culture.

(7) To encourage pupils to transfer mathematical knowledge and skills to other subject areas.

(8) To highlight the intellectual development which the study of mathematics can provide.

(9) To give pupils:

(a) a core of essential mathematical knowledge and skills necessary for everyday life

(b) the necessary mathematical knowledge and skills required for both vocational training and further education.

(10) To help pupils appreciate the normal algorithmic processes and use them with understanding in the solution of problems.

(11) To help pupils recognize the unified structure of the subject and integrate the separate branches when solving problems or carrying out investigations.

B. A suggested core of 'essential' mathematics

(1) Mathematical processes, knowledge and skills necessary and desirable for daily life at present and in the immediate future:
basic money management courses, comparing, sorting and ordering, generalizing, measurements, reading instruments, time-tables, recording data.

(2) Some facility in mathematizing situations at an elementary level - to be achieved by such activities as solving mathematical games and puzzles, looking for similarities, experimentation, trial and error and project work etc.

(3) The ability to read, construct and interpret charts, tables and graphs which are in common everyday use.

(4) The development of competence in basic computational skills including:

taxes, rates, insurance, wages, work-rates, prices, familiarity with the use of calculators, estimations and approximations.

(5) Competence in basic number and spatial properties to ensure that computations and applications are achieved.

C. Options

A suggested list of 'options' is given below to be presented at different depths and by a variety of media including individualized instruction:

Algebra; Geometry; Statistics; Sets, relations and functions; Cylinder, sphere and cone; Indices, logarithms and surds; Trigonometry; Flowcharts and mathematical programming; Co-ordinate geometry.

In an attempt to receive feedback on this proposition, the author invited comments from three pupils and two mathematics colleagues (Jim and Eddie) in his own school. A local third-level lecturer (David) with an interest in mathematics education also offered his comments.

Pupils perceived the element of 'choice' to be an important advantage over the present course as evidenced
by the following comments:

1. The idea of choice appeals to me instead of having to do everything in the set course especially if one of the options involves using the microcomputer to help us understand things better.

11. Giving us a choice of modules will cut down on the workload as there is too much at present. It will give us more time for revision and to concentrate on some things in more detail.

Another pupil valued the notion of 'essential' mathematics:

If 'core' mathematics means we will spend more time on mathematics that we will need when we leave school then it's going to be very useful as the basics aren't taught after Junior cycle.

Positive features of the modular approach, according to Eddie and Jim, include its potential for integrating different mathematical topics, increasing student motivation and their enjoyability of the subject:

1. This will require a lot of work but it will mean that students will experience more success. Student motivation will improve and mathematics should be perceived as a more enjoyable subject.

11. The most appealing aspect for me is the attempt it makes to provide for two distinct target groups. I also think that with careful planning, the modular structure can provide an ideal opportunity to integrate the various parts of mathematics.

In the eyes of Eddie and David there were some perceived difficulties in relation to implementation:
Assessment may well cause some difficulties but this problem can be overcome. At another level how will mathematics teachers become acquainted with and implement the modular approach? Much in-service and resources will be required.

Further work is needed on how your core list is to be sequenced to accommodate the various stages of mathematical learning.

A number of suggestions were received for future research with the modular approach:

I suggest that applications of each mathematical module be found and taught during the 'option' courses.

I like the way your 'core' does not concentrate solely on computational skills. In addition, a useful task might be to define levels of competency for Junior cycle pupils for each area in your list of essential mathematical skills.

Is it conceivable to have a modular mathematics curriculum facilitated by mathematics resource centres in schools where students might attend for some timetabled classes and have access to a variety of learning resources including specialist expert or tutorial help for consultation purposes?

The above exercise, while of a limited nature, is offered as the author's contribution to an urgent problem - that of restructuring the secondary mathematics curriculum - currently facing mathematics educators and teachers in Ireland. In a sense it constitutes a practical example of empowerment in action by a practising mathematics teacher.
9.5 Appraisal and Empowerment: an important synthesis

9.5.1 The relationship between appraisal and empowerment

In arriving at a rationale for appraisal it was pointed out that appraisal is a process which holds many benefits for mathematics teachers, schools, pupils and society. It has the potential to foster self-esteem, self-confidence and increased self-awareness and in general more effective mathematics teachers. It was observed that teachers value opportunities in the appraisal process to talk about constraints imposed on them. This process of helping mathematics teachers gain a degree of control over their professional work, of assisting them to make and implement informed responses and decisions in their teaching despite pressures and constraints, is very much akin to the process of self-empowerment just described.

Smyth [128] puts this analogy of the purpose of appraisal (or clinical supervision) as follows: (P.8)

Viewed as a form of empowerment, clinical supervision amounts to a way of transcending the technicalities of teaching, investing us with the capacity to explore, understand and transform our own thinking about both the means and the ends of teaching.

In formal appraisal, the author emphasized that appraisers need to keep the individual mathematics teacher's view of teaching and his meanings in mind and exhibit respect for the way mathematics teachers see their practice. This again resembles an important aspect of the empowerment strategy described earlier in which teacher perceptions and understandings are acknowledged as critical. In this connection, the empowering potential of Smyth's concept of clinical supervision is of value to appraisers involved in formal appraisal of mathematics teachers. It proposes to appraisers an aim and style that involve [127]: (P.180)
making activity meaningful for others. In other words, providing others who work with us a sense of understanding where they have come from, what they are doing and where they are heading. This involves working with people rather than on them, so they can focus on what they do in the dailyness of their teaching, extracting meaning from it, and in the process communicating about the nature of those meanings.

(The author’s italics)

Self-appraisal can be considered an empowering experience in which mathematics teachers probe their own experiences, uncovering meanings and seeking explanations so as to enable them to develop new understandings, aims and possibilities and the generation of theories from their own practice.

Peer appraisal can be viewed as a creative process where two mathematics teachers actively seek to empower each other, sharing similar concerns and attempting, if necessary, to change features/elements of the context in which they work. By taking more control and responsibility at all levels of their professional work, mathematics teachers can assist in developing a much needed co-operative teaching profession, one which promotes mutuality amongst colleagues. This stands in contrast to the present secondary school scenario where mathematics teachers, in general, guard their own classroom teaching in a competitive atmosphere. Mathematics teachers are therefore being encouraged to become involved in a proactive and empowering process, one that offers more for less, a process that will serve them well on a number of important counts as elaborated by the author in the previous section.

A model which shows the intertwining and meshing of the two processes – appraisal and empowerment – is given in Figure 13. The model presents the current depowering
Figure 13: Appraisal and Empowerment: A Strategy for the Improvement of Mathematical Education
reality for mathematics teachers as a constraint and attempts to show, how through the twin processes of appraisal and empowerment, that this need not be the case. The model as envisaged by the author is a continuous and iterative process, offering a strategy for rendering key issues in mathematical education problematic and the subsequent generation of possible solutions and alternatives. The role of empowered mathematics teachers in task-directed groups is an integral part of the model. The model propounds that appraisal and empowerment can enhance the professional development of mathematics teachers and in the process improve pedagogy and teaching performance. At 'system' level, it has the potential to effect better planned, creative and more responsible mathematical change.

All educational change implies a theoretical stance on the educator's part. Such a stance involves an interpretation of man and the world. Appraisal, as a form of empowerment, believes that mathematics teachers are charged with developing themselves. It does not say that each individual person is completely capable and self-sufficient as that would clearly be foolish. It also acknowledges the primary importance that must be attached to the individual nature of a mathematics teacher's perception of the world in which he lives and works. The potential of the model is unlikely to be realized without the inbuilt support element from the Ministry of Education and schools.

It would be fallacious to think that the model presented in Figure 13 will become operational in isolation from other realities. Some of the implications of working with and implementing the model are now considered.
9.5.2 Implications and outcomes

At teacher level, individual mathematics teachers are likely to begin to speak more openly about what they feel and think, become more aware of themselves and each other, and of the relationships and the complex interpersonal dynamics at work in the school system. They will become more aware of skill levels or the lack of them, and will probably demand more opportunities for school-focused in-service education, more forums to discuss issues which affect them personally. This in turn implies that Ministries of Education need to measure the 'capital' that is available to support the empowerment ideal where 'capital' includes finance, talent and goodwill. As individual mathematics teachers acquire new awareness and develop skills then they will apply and practise them. The system must be alert to and prepared to accept that creative and responsible change can be a consequence. There are likely to be professional implications for mathematics teachers engaged in the model process; for example, an expanded self-awareness can lead to a situation where one challenges some of the ways in which one operates and ponders on the justification and place of mathematics. This is understandable as some of the process skills advocated in appraisal and empowerment require more personal involvement which are directly linked with school-life issues. Clearly also, appraisal in the context of empowerment challenges mathematics teachers to undertake programmes of personal development and skill acquisition which will enable them to model the competencies that they would like their pupils to attain.

The empowerment notion implicit in groups of mathematics teachers engaging in productive 'deliberation, experimentation and evaluation' activities is likely to make demands on mathematics teachers' judgments and practical reasoning that go far beyond those of everyday
practice. What most mathematics teachers accept as taken-for-granted normal practice will now become problematic. Against these demands, the move towards considering one’s teaching in terms of fundamental principles that are in turn based on values and ends, holds the potential to be profoundly empowering.

The model also has implications at school level. Clearly, it’s not enough to believe in the importance of the individual mathematics teacher and in his own self-reliance and competence in dealing with teaching problems, if the school ethos and pupil-teacher and teacher-teacher relationships are inimical to such concepts. It is an approach which challenges schools to provide a climate favourable to systematic review and reflection and teacher professional development on a school-wide basis. A school ethos which is authoritarian or highly regulatory will have difficulty in enabling such a process of personal and skill development. There is something ludicrous about processes like appraisal and empowerment which urge mathematics teachers to take personal control, to make and implement informed decisions, to engage in peer and group-orientated tasks while their experience is of institutions in which staff have no such freedom of operation and are enmeshed in authoritarian power structures. Thus, the appraisal and empowerment model presents a fundamental shift in emphasis for schools with a traditional management style. Clearly, the model is unlikely to graft onto school structures that exhibit mechanistic features.

The collaborative nature of the appraisal and empowerment process indicate a concern with democratic values and it can thus be conceived as anti-hierarchical. This can be seen as increasing the difficulties not just of beginning but also of continuing in a firmly hierarchical school. In the absence of a participatory and open style of management, empowered mathematics teachers will question the authenticity of the nature of leadership and authority
within their own schools. Thus, the introduction of the model reiterates the urgent need to provide management development courses for Headteachers and senior staff to ensure that the model is given a chance to put down roots.

Finally, the model poses significant implications at system level for how mathematics teachers are trained and educated. In uncompromising terms, the pre-service training of mathematics teachers must place a higher premium on the professional knowledge which mathematics teachers can achieve through their own reflective and deliberative 'action-research' style approach. This is necessary if mathematics teachers are to be brought to the point where they accept that a vast amount of rethinking is necessary firstly for its own sake and secondly because of the information revolution. If what goes on in the classroom really counts then pre-service training must provide a pedagogy where self-empowerment and the urgent need for reflection on classroom practice command higher status. Subsequently, further development during their in-service years is dependent on mathematics teachers having available to them continuous 'after-care'. The instrumental importance of the group and the time spent in group activities of various sorts is disproportionate to the limited knowledge of group dynamics. The non-productivity of termly or yearly staff meetings is an example. If the concept of empowered and task-directed groups of mathematics teachers is to achieve its excellent potential then it follows that during the pre-service stage of training, mathematics teachers ought to have adequate opportunities to acquire insight into and practise the fundamentals of group dynamics in thorough fashion.
9.6 Summary and Conclusions

In the past, mathematics teachers have allowed too many non-professionals to pontificate to them on curricular and professional matters. For too long, the 'Humpty-Dumpty' approach has characterized the response of mathematics teachers to the difficulties encountered in their working context. This latter approach involves mathematics teachers blandly acknowledging what is happening, sometimes even making sympathetic noises, but still sitting kicking on the fence, waiting for more constraints, frustrations and anger to tip them off.

The praxis of mathematics teachers accepting imposed decisions is an acquiescent and insufficient response. This Chapter has suggested a need to move from inadequate responses towards empowerment. This latter concept involves the mathematics teacher exercising more personal control over professional issues and acquiring an increased capacity to subject his working context to scrutiny by considering mathematics teaching and how to teach problematic. To this end, the author's proposed strategy for differentiation at Junior cycle was offered as one practical example of empowerment in action. In turn, this represents a means of enhancing the professional development of mathematics teachers.

Empowerment as a concept applies to all teachers. The next chapter is an attempt to customize the process for mathematics teachers: how does the notion of empowerment apply especially and specifically to mathematics teachers? What unique traits and characteristics distinguish the self-empowered mathematics teacher from other mathematics teachers? Does he confer on secondary mathematics education any significant advantages? In attempting to answer these questions, the next chapter utilizes insights and understandings acquired earlier in this thesis which portrayed various dimensions of the self-empowered mathematics teacher.
CHAPTER 10

THE SELF-EMPowered MATHEMATICS TEACHER AND PRACTICAL ILLUSTRATIONS

10.1 Introduction

Throughout this research thesis, the author has propounded a variety of different perspectives on the self-empowered mathematics teacher. The previous chapter suggested the concept of empowerment as an appropriate intervention strategy in the context of the current depowering and disabling Irish secondary school system. It is now both timely and necessary to integrate the various perspectives presented in an attempt to characterize the self-empowered mathematics teacher. What traits and attributes does he possess? What kinds of activities will he engage in? How is he different from other mathematics teachers? How will he benefit secondary mathematics education?

In seeking to answer such questions, this chapter focuses on the self-empowered mathematics teacher as a concrete identity. Key characteristics, attributes and activities which the self-empowered mathematics teacher will engage in are identified and elaborated in the context of secondary mathematics education. Potential benefits are highlighted and the chapter culminates in the presentation of a functional model of the self-empowered mathematics teacher. The author has collected together, from his own personal experience, a number of interventions and outcomes effected at classroom level. These are integrated into the text throughout the chapter and presented to the reader in an attempt to give practical
illustrations of the self-empowered mathematics teacher in action.

10.2 Traits and characteristics of the self-empowered mathematics teacher

For ease and coherence, the author presents a characterization of the self-empowered mathematics teacher under a number of summary headings.

10.2.1 The self-empowered mathematics teacher as a contributor to general educational goals

The self-empowered mathematics teacher (hereinafter referred to as SEMT) will be aware of some of the ways in which mathematics can contribute to general educational goals. SEMT's will know that mathematical education, by developing 'critical powers', enables pupils to develop a critical attitude to numerical information presented to them in this information age. Secondly, SEMT's will realize the role that mathematics can play in the exemplification of certainty. Students and adults now live in an era in which insecurity and uncertainty are more widespread than in any previous generation. Although secondary school does provide a 'stability' of a sort, only in the subject of mathematics is there verifiable certainty as subjective opinions emerge as problematic in most other subjects. The teaching style of SEMT's will be such as to encourage and enable pupils to come to such 'truths' and convictions for themselves. Thirdly, SEMT's will be conscious of the aesthetic side of mathematics and the pleasure which this can bring. As mathematics teachers they will endeavor to create a positive attitude towards the subject and help students to experience such pleasure. In practice, an emphasis on open-ended investigations in the mathematics classroom is one possibility of enabling more students to experience the
possible aesthetic rewards from mathematical education.

Finally, SEMT’s will be aware that the service role of mathematics is becoming increasingly important. In his teaching, he will be alert to the ways in which such subjects as biology and geography have become more quantitative thus allowing new opportunities for co-ordinating school work and for displaying the power of mathematical applications.

In the author’s case, he co-ordinates the teaching of percentages with the commerce teacher, statistics with the geography teacher and the metric system and formulae manipulation with his science colleague. This collaboration and ‘cross-curricular’ emphasis is appreciated by the pupils. Pupils have commented that they find the reinforcement of computational skills beneficial.

10.2.2 The ‘technologically’ aware mathematics teacher

In the coming years, mathematics teachers will be under considerable pressure to demonstrate that they are technologically aware. SEMT’s will be sensitive to the changes of curricular emphases which microcomputers have brought especially in the areas of algorithmic processes, discrete mathematics and symbolic manipulation. Moreover they will be aware of the varied ways in which the microcomputer can be used as an aid in mathematics teaching and learning:

- as an electronic blackboard or teaching aid for the mathematics teacher
- as a tutorial aid for the student to enhance learning aided by computer software
- for individualized instruction of pupils
- as a tool which will perform calculations, evaluate and plot functions etc.
- as a means for experimentation, investigation and exploration.

The use of computer technology to encourage experimentation and investigation is of particular importance as exploration and discovery are important components of the educational process of mathematics. At a time when there are new pressures to cut down on traditional curriculum content, SEMT's will be in a position to collectively assert the benefits of using computers to improve pupils' understandings of such traditional areas as calculus and geometric transformations or even in such areas as statistics and probability where the gains from being able to simulate are enormous.

In recent years this has been one area where the author has invested much time and energy. One such attempt involved the author using a professionally designed statistics software package as a teaching aid during the teaching of descriptive statistics to a Junior cycle mathematics class. A fully equipped school computer laboratory comprising sixteen BBC microcomputers in an Econet network provided an ideal facility. A worksheet (Appendix K) was produced with problem-solving questions of varying difficulty and some of these involved pupils doing investigational and exploratory work. The worksheet also gave pupils an opportunity to comment on their experience (new for them) and to make suggestions for improvement.

The fact that the activity was enjoyable was mentioned by two pupils:

I First it was enjoyable. I have never been great at statistics but this helped me a lot. It shows statistics in a whole new light and the colour and sound were excellent.

II With computers you can take the subject
another step onwards and even enjoy the subject.

There was almost unanimous agreement among pupils regarding the ability of microcomputers to enhance their understanding:

I Because it helped me understand what we had done in class it made me more interested in the topic and gave me a new liking for mathematics.

II The computer helped me to understand the topic better especially when the charts were printed up on the screen.

The 'user-friendliness' of the software was also perceived to be important:

It was very easy to use and helped clear up some doubts I had. I thought first it was going to be very difficult.

Arriving at a relationship between microcomputers and mathematics was an important outcome for another pupil:

Even though we do computers and mathematics separately this was the first time both came together. I suggest that computers be used more in the teaching of mathematics. They make mathematics more easier.

Other areas where the author has experimented with the microcomputer as a teaching aid include quadratic equations and trigonometry.

It is likely also that the inductive paradigm - compute, conjecture, prove - which can be employed in many different situations will find a place in the teaching of mathematical topics. Although the use of spreadsheets and computer aided design packages have still to be properly developed and tested, SEMT's will be open to their
potential for influencing mathematics teaching as the next millennium is ushered in.

SEMT's will not neglect either the essential role which calculators can play in the mathematics curriculum:

- as an aid in the acquisition of the important skills of estimating and approximating
- as an aid in building a positive attitude to calculating and arithmetic
- to assist in the teaching of statistics, series, factorial, exponentials etc.
- as a means of exploratory and investigational work where number properties can be explored, hypotheses tested etc.

The fact that the use of calculators is not permitted in the Irish mathematics examination at Junior cycle did not prevent the author from instigating an important initiative in this area. He recently acquired a set of standard scientific calculators for use by himself and other mathematics teachers as a teaching aid at no extra cost to the school. This was achieved through the selling of an unused and relatively out-of-date microcomputer. Appendix L displays a worksheet which gives the reader some indication of how the calculator was used by the author in the teaching of estimation and approximation skills, squares, square roots and reciprocals. Some of the questions involved problem-solving and investigational activities. Similar worksheets were produced as resource material in the teaching of decimals, percentages, fractions and conversions. Some of the author's peers have adopted or adapted these worksheets for their own personal use in their mathematics teaching.

Pupils' reactions from using the calculators have been favourable. Such comments as 'it was enjoyable and interesting' or 'it was a break from the routine' were common. The major limitation for the author has not been 'how can I use the calculator to enhance pupils' mathematical learning?', rather, 'how much time can I
afford to give to activities with the calculator?’.

Thus, in the future, SEMT’s will be in a better position to face the problem area of how technology can and should influence the teaching of mathematics.

10.2.3 The self-appraising and effective mathematics teacher

The model for effective mathematics teaching as propounded by the author in this thesis emphasized a variety of factors ranging from skill acquisition to teaching style. He has sound subject knowledge together with the ability to display a variety of teaching methods from exposition to practical, project and investigational work. Problem-solving will be emphasized as will the relevance and applications value of mathematics. Computer technology will be utilized to enhance mathematical understanding and learning. SEMT’s will view pupils as an important input variable and an integral part of the learning process and not as passive recipients of knowledge or ‘fodder’. They will show concern and caring for their pupils, encouraging them to take responsibility for their actions and progress.

Affective and effective skills are becoming increasingly more important in a technological society. Consequently, the author placed particular emphasis on effective mathematics teachers possessing process skills. SEMT’s will be alert to and acquire a variety of these including:

- decision-making skills
- peer skills
- conflict-resolution skills
- information-processing skills
- resource-allocation skills
- skills of leadership and introspection.

Conflict-resolution skills (or intrapersonal skills)
relate to the mathematics teacher's ability to handle conflict, worries and concerns both within and outside the classroom. At a time when mathematics teachers are being bombarded with a host of external pressures together with increasing teacher stress, the development of intrapersonal skills is particularly important. This is not to suggest that SEMT's will be able to remove many of the external pressures (as clearly many are not removable), rather that skill development in this area will mean that intrapersonal conflicts will be handled with more ease and less strain. For the mathematics teacher such intrapersonal difficulties might include the managing of heterogeneous classes, the emphasis by school principals, parents and others on measurable achievement by students or the fear of being held accountable for student failure.

Exploratory and investigational work by mathematics teachers using the computer as envisaged in the previous section might well prove difficult as it is likely to disturb the normal teacher-pupil relationship. Likewise, an emphasis on problem-solving by mathematics teachers is a demanding and risk-taking business as it requires the mathematics teacher to desert the familiar for the strange. In both cases, SEMT's will be individuals who will gain the confidence to live with a degree of insecurity and in the process acquire coping skills. Thus, emotional resilience and tolerance to work and cope under pressure are important and valuable characteristics of SEMT's together with having the courage to do what is right even though it might be personally stressful and unpopular with others.

Furthermore, SEMT's will be aware that the effectiveness of their teaching is not unaffected by school processes operating within the school organization, albeit that the relationship is a complex and intricate one. The existence of SEMT's in schools will be one reason as to
why schools actually do make a difference.

A primary characteristic of effective SEMT's will be their ability to 'self-appraise' using action-research techniques in a routine fashion. Self-appraisal using action-research procedures encourages the mathematics teacher to identify and investigate problems related to his own practice and to propose, implement and evaluate remedies to help improve the effectiveness of his teaching. By so doing, mathematics teachers will be encouraged to make and maintain basic changes in key areas of their teaching. What areas of concern might SEMT's be interested in improving through action-research and self-appraisal? Classroom management, methodology and teaching styles, professional attitudes, concept development, use of microcomputers are some problematic and interesting aspects which could be examined.

One action-research technique utilized by the author over a three-month period in 1985 involved the completion of a log-diary on a daily basis. At the end of each mathematics lesson, the author would reflect and write down brief notes on 'good' and 'bad' lessons, unusual incidents, pupil difficulties etc. An analysis at the end revealed that the author's most successful mathematics lessons were characterized by:

- careful planning
- good relationships with pupils
- positive attitudes of pupils
- making the mathematics teaching applicable to students' own lives
- the author's own enthusiasm
- variety of teaching aids
- fortunate remarks and interventions by pupils
- problem-solving activities at the correct ability level.

The least successful lessons were characterized by:

- inadequate preparation
- unsupportive class attitudes
- poor personal relationships with classes
- unfortunate incidents and conflicts in the class
- unclear explanations and interventions
- lack of motivational materials
- allowing marking to take precedence over lesson preparation.

Some of the improvements and purposeful changes in the author's teaching behaviour resulting from the diary reflections involved:

- less talking by the teacher and more individual work and contact with pupils
- keeping up-to-date with marking
- the improvement of worksheets by ensuring that pupils (especially those at the lower end of the ability spectrum) do not experience any problems of conversion from the language used to the mathematical problem or of interpreting the answer to the problems in language terms
- in some cases, with difficult classes, reading back to pupils the author's own diary reflections in an attempt to encourage pupils to reflect about and modify their interactions and behaviours in the classroom
- paying special attention to classes with less able pupils; in this connection allowing pupils to experience success in mathematics was found to be essential together with an emphasis on simplicity and flexibility
- making a collection of mathematical puzzles and mathematical games which are used by the author in odd moments of lessons, at the end of term or when suitable homework cannot be set. These motivational materials have been kept together and recorded on index cards which contain brief notes on when they were used, with whom and their success. Appendix M provides the reader with a sample collection obtained from books and magazines.

SEMT's are also likely to engage in peer/collegial appraisal with an emphasis on deciding criteria for effective mathematics teaching before classroom observation. They will also be open to the use of audio and video techniques along with pupils as additional sources of feedback on their teaching performance. These processes of self and peer appraisal (using a combination of some or all of the techniques advanced by the author in
this thesis) will confer on SEMT's a decided advantage when formal appraisal inevitably arrives. SEMT's by engaging in such processes will exhibit proactive orientations and thus help play a meaningful role in improving the quality of their mathematical education through improved pedagogy.

10.2.4 The innovative, entrepreneurial and 'lighthouse' mathematics teacher

Significant changes in school mathematics will only be achieved if there are marked changes in the perceptions and attitudes of mathematics teachers. A primary consideration in this connection is the degree to which the teachers are open to new ideas, new innovations and new practices. The teacher’s role in mathematical change is crucial. SEMT’s will be able to accept this new role which will foster their professional development. On the condition that they are provided with suitable support and incentives, SEMT’s will:

- be willing to 'try out' a variety of teaching approaches in their classroom including investigational and practical work
- have the courage to use a variety of teaching aids including microcomputers, calculators and video-tapes which have yet to be successfully incorporated into schools
- engage in mathematical discussion with pupils and talk more about mathematics
- have the drive and will to pursue goals
- be willing to engage in innovative action-research
- have the courage to engage in self and peer appraisal.

The author has seized an opportunity to use the excellent videotaping facilities available in the school in an attempt to develop the mathematical awareness of his pupils. A series of television programmes on the history of mathematics from Greek civilization to modern times were recorded by the author and these are now shown at
suitable times during the year to his mathematical classes. Apart from giving pupils an indication of how the various branches of mathematics evolved, the author has also found that the programmes can be used as a 'trigger' to promote discussion.

When the occasion demands, the SEMT will not be averse to substituting his traditional role of 'supreme-answer-giver' to that of guide to pupils' learning and the designer of a curriculum which makes use of a variety of different resources including computers, booklets, videos, peer group interest and other assistance. In the classroom, SEMT's will exhibit a less constrained and more open pedagogical style which would involve helping students to reflect on their mathematical knowledge, helping them to become aware of what they know and how they learn. Approaches other than class teaching will be evident. Among SEMT's there will be undoubtedly a number of energetic and creative individuals who will seize opportunities as they emerge. In the absence of the formal introduction of structured Heads of Mathematics Departments in Irish secondary schools, experienced SEMT's who have particular expertise and interest will be suitable candidates to take on an important role as mathematics co-ordinators.

Textbooks will continue to be a major medium through which new ideas and teaching methods will be disseminated. Apart from visual advances, Irish mathematics textbooks have changed little in recent years. With the availability of high quality word processors and low cost printers it is now technically feasible for schools to construct and print their own textbooks. A data bank of licensed material could be one outcome by groups of SEMT's who might decide to take on such an entrepreneurial role either within their own schools or as a collaborative venture between schools.
The author has already drawn attention to a number of innovative and entrepreneurial activities effected at classroom level. His initiative in the area of calculators represents a modest first step towards securing a more privileged position for electronic calculators in the context of mathematics teaching in his own school.

His continuing attempts to enhance his mathematics teaching using the microcomputer is further testimony of his willingness to engage in new innovations and new practices to improve the quality of pupil learning. An extension of this activity has involved the author travelling some sixty miles, once a term, to a regional Micro Electronics Project (MEP) Micronet Centre located at the University of Ulster at Coleraine, to evaluate the impressive collection of mathematical software for school use. One productive outcome has been the establishment of a mathematics software library in his own school. Colleagues, impressed with the potential of the software for their own mathematics teaching, now accompany the author on these ‘cross-border’ excursions. Neither was the author unwilling to provide a seminar on the merits of action-research to colleagues (see Chapter 4) in his own school when requested to do so.

Such innovative characteristics and traits will effectively mean SEMT’s taking on the role of ‘lighthouse’ teachers who point the way to others by demonstrating what is possible within their own classrooms.

10.2.5 An autonomous agent in the practical business of mathematics curriculum development

Curriculum development is an urgent professional problem currently facing Irish secondary mathematics teachers. A
reversal is needed from the present scenario in which mathematics teachers are being confined largely to the implemented curriculum, decided upon by outside agencies. SEMT’s will be actively involved in the ‘planned, implemented and assessed’ mathematics curriculum. This involvement by mathematics teachers in planning, process and evaluation is crucial. Through the empowering potential of planning, processing and evaluating (or action-research), SEMT’s will be engaged in exercising their proactive qualities and acquiring the skills called upon in curriculum change: analyzing, evaluating, justifying, planning, testing, implementing and reviewing. By so doing, SEMT’s will be regaining a degree of personal control and influence on the mathematics curriculum which has been denied to them for much too long.

The experiences of visiting the MEP Micronet Centre, as mentioned above, allowed the author and his colleagues to practice and sharpen their skills of ‘testing, implementing and reviewing’ appropriate mathematical software.

The author’s interest in mathematics curriculum development has not been confined to the classroom only. In 1987, the school principal, aware of the author’s interest in school mathematics education, invited him to prepare an information sheet for the benefit of those parents whose pupils were about to undertake the recently revised Junior cycle mathematics courses. The author’s response is reproduced in Appendix N for the reader to consult. Two colleagues of the author who admitted to being ignorant of recent developments in Junior cycle mathematics also appreciated the information sheet.

SEMT’s will not be confined to curriculum development work at the individual teacher level. As a creative member of task-directed groups, SEMT’s will be involved in rendering
key mathematics curriculum issues problematic as explicated by the author in the previous chapter. Alternatives to the present 'compartmentalised' and linear mathematics curriculum will be explored including an evaluation of a restructured mathematics curriculum on the basis of applications, modules or processes. SEMT groups will thus be involved in designing relevant courses which will attempt to meet the needs of the entire ability range especially those to be found at both extremes of the range. By engaging in cyclical and iterative cycles of 'deliberation-experimentation-evaluation' these SEMT groups will address key questions of mathematics curriculum design:

what is it that we want pupils to learn?
how is the learning of mathematics to be structured and how is the students' acquisition of such structures to be facilitated?
how can the new framework reflect and illuminate a new comprehensive set of mathematical aims and objectives?
how can the mathematics curriculum cater for the different forms of mathematical knowledge?

The modular approach described in the last chapter provides concrete evidence of the author's own reflective work in the search for a new alternative mathematics curriculum.

With the new Junior cycle mathematics syllabi came a plethora of textbooks, each one proclaiming to be an advance on those produced by competitors. The author decided to compile a complete set of all new available mathematics textbooks with a view to reviewing them and deciding on the most suitable for his own school. This was considered a significant and worthwhile task by the author, not because of his reliance on textbooks per se in the classroom, but because it is widely acknowledged that textbooks will continue to remain the major medium for the dissemination of new mathematical ideas and teaching methods. This initiative concluded in a satisfactory
manner by the author arranging a meeting for his mathematics colleagues at which a consensus emerged concerning the most appropriate set of textbooks for the teaching of Junior cycle mathematics in the school.

SEMT's will also be conscious of the cultural curriculum and how the school mathematics curriculum can both reflect and contribute to the Irish culture. In their class teaching they will emphasize the history of Irish mathematicians to help foster a sense of pride and 'ownership' of mathematics.

In general, SEMT's will thus help curriculum developers in key areas of curriculum design so as to encourage and support good teaching and worthwhile learning in the subject. It is through these experiences of deliberating and experimenting on curricular alternatives and crucial curriculum design questions that enable mathematics teachers to become autonomous agents in the practical business of mathematics curriculum development.

10.2.6 The 'reflective' and 'extended' professional

Irish secondary mathematics teachers are currently characterized by their low level of professional authority and autonomy combined with acquiescence, traditional routines and isolation (see Chapter 3). Furthermore, in the bulk of secondary school classrooms, a stereotyped form of mathematics teaching is likely to be found which relies heavily on the textbook and the traditional teaching pattern of exposition-examples-exercises. Apparatus is rarely used and class teaching is the norm. This 'restricted' professional is characterized as intuitive, classroom-focused and works from experience rather than theory. In contrast, SEMT's will approximate to the 'extended' professional [81] locating his work in a broader context, including comparison with others, self-
appraisal and a concern for theory and its relation with practice. The author's own personal experiences of engaging in the processes of self- and peer appraisal have already been described in Chapter 7.

One attempt by the author to locate his work in a broader context involved him visiting three large firms in the locality and talking to the respective personnel managers regarding the mathematical requirements which they expected of new entrants. A consensus emerged that the current Irish Senior cycle mathematics programme did not facilitate the needs of employers. The author communicated this feedback to his school principal and suggested the adoption of the North Tipperary Alternative Mathematics Programme (see Chapter 2) as an alternative for weak pupils doing Leaving Certificate mathematics. This request was refused on the grounds that the suggested alternative mathematics programme presented validation problems.

The SEMT will also have a genuine liking and interest for the teaching and pedagogy of mathematics and will not rely on 'slavish adherence to textbooks' [67]. As a 'reflective' practitioner he will explore what is known about mathematical learning and about what can happen in the classroom and try to use this knowledge in his teaching. This will be facilitated by engaging in such reflexive questions as:

what am I doing in my classroom?  
why am I doing what I am doing?  
what effect do my teaching behaviours have on my pupils?  
what do I really want my students to learn?  
how will I ensure that they achieve these aims?

SEMT's will thus be characterized by their increased capacity to re-appraise their own thinking about their practice and about the ideological and institutional context of their work. By adopting a research and
development role they will come to realize the value of their own pedagogical knowledge and the contribution it can make in improving their teaching situation. The pilot study on pupils' attitudes to school mathematics, as contained in Chapter 4, provides firm evidence as to the author's commitment to research on important issues affecting his mathematics teaching.

Through the praxis of action-research SEMT's will learn how to develop ways of framing their own problems and action-plans. A routine ritualistic method of teaching which encourages mathematics teachers to 'celebrate' classroom problems in a passive and inactive fashion will be replaced by a proactive and reflective approach. In this way, SEMT's will become accustomed to generating useful and valuable knowledge about their own teaching and not accept prescriptions given to them from outside agencies. It is not the author's intention to propound a view in which mathematics teachers are being continuously filled with pedagogical knowledge in order to become converted or elevated to the level of self-empowerment. Most experienced mathematics teachers already have considerable pedagogical knowledge, but being empowered implies they recognize and value this knowledge and use it to improve the effectiveness of their teaching.

It is fair to say that SEMT's will be more than just subject specialists who prepare their pupils for success in State examinations and university entrance points in a highly centralized system of education. They will not, for example, allow the institutionalization within schools to distort the links between mathematics and reality. They will be conscious of the gender problem in relation to secondary school mathematics. Although it is not proving easy to correct gender biases, empowered mathematics teachers will at least ensure that the impact of technology does not exacerbate the situation. Empowered mathematics teachers will also be more ready to
accept continual responsibility for their actions as professionals and for self-improvement together with the maintenance of proper professional codes of conduct. This 'extended' professional perspective which will characterize SEMT's can thus be articulated in the broader mathematical context. Some additional dimensions are now considered.

The SEMT will be aware that mathematics now plays an increasingly important role in society and this will be communicated to his students by assisting them to appreciate the uses of mathematics. Non-empowered mathematics teachers are unlikely to give this aim attention and instead concentrate upon the learner's acquisition of skills and techniques. Secondly, the SEMT will know that there is an alternative view to the current 'content-orientated' approach to secondary school mathematics, one in which the task of the mathematics teacher is to help students to learn how to 'mathematize' through various kinds of mathematical processes. In the technologically new circumstances which schools must adapt to, such processes would include comparing, ordering, abstracting, symbolizing and generalizing. Furthermore, SEMT's in-task-directed groups will research into the kinds of problem situations and teaching materials that can best assist students to develop the ability to mathematize. Thirdly, SEMT's will realize the importance and usefulness of 'mathematical modelling' and the motivation which such activities (especially project work) have for further study in the subject. He will be aware that to learn about mathematical modelling involves a shift to a different level where many models are considered and to abstract principles and procedures embedded in them.

Finally, SEMT's will ensure that their students will be given opportunities to experience aesthetic pleasure from their mathematical education. They will help them to appreciate that with mathematical knowledge and
understanding they acquire desirable power which can assist them in the solution of their own problems and in their own decision-making. By alerting students to, and giving them examples of, the ways in which mathematicians search for common structures, SEMT's will be helping students to appreciate how mature mathematicians work.

At a more general level, SEMT's will be conscious of their adverse professional position, of what the system is doing to them in terms of teacher control and the depowering effect of the forces and factors which shape and constrain their professional attitudes. However, as empowered and self-directing individuals, they will have the confidence and skills to overcome the restraints on their power to act effectively (either individually or with other mathematics teachers who share the empowerment ideal) and not become disillusioned by the disabling forces being exerted on them. Non-empowered mathematics teachers on the other hand will not possess this expanded self-awareness and will continue to be dominated by traditional routines and isolation culminating in stunted professional growth, stagnation and an introverted attitude to mathematical change.

10.3 Benefits for mathematical education

The above profile of the self-empowered mathematics teacher is not intended to be either prescriptive or exhaustive. Furthermore, the category headings are clearly not mutually exclusive. The concept of the self-empowered mathematics teacher confers on mathematical education a number of significant benefits. These can be articulated at a number of levels.

At classroom level, individual mathematics teachers will
acquire a new professional perspective on their work, one which transcends the 'restricted' and ritualistic image currently dominating the profession. Mathematics teachers will be more aware of their strengths and weaknesses, of new trends and developments in mathematics education, more aware of their skills or lack of them, more able and willing to challenge their own and other's accepted practice, norms and assumptions. Although aims and objectives are a basic part of the training of mathematics teachers there has been an ongoing failure to practise their implementation. The concept of SEMT's represents one means of narrowing the gap between theory and practice and in the process help mathematics teachers internalize what is intellectually recognizable as valuable. This will be greatly facilitated by such processes as self-appraisal and action-research. No longer will difficulties and failures remain only a set of frustrations to be endured. The proactive orientations of SEMT's will help them to consider teaching and how to teach problematic and to perceive teaching difficulties as an agenda of problems to be worked at.

The concept of self-empowerment will thus help significantly to prevent apathy and inactivity from becoming the norm through self-enhancement. In their teaching, the gap between intentions and actions will be reduced and empowered mathematics teachers will exercise greater personal control over aspects of their teaching. The ultimate hope is that empowerment, by enhancing the professional development of mathematics teachers and in the process improving pedagogy and teaching performance, will benefit pupils by an improved quality in their mathematical education. Thus, empowerment represents one means of helping mathematics teachers acquire the skills for effective mathematics teaching, of obtaining a window on their teaching values and philosophies. It is a process designed to transfer more power about teaching and pedagogy into the hands of mathematics teachers. Their
professional perspectives will not be limited or constrained by routine, custom, central regulations or the depowering effect of repressive school structures.

In the author's own school, these institutional constraints are much in evidence with traditional routines, insufficient time for reflection and the absence of any policies in curriculum and staff development. However, the author has refused to fit the institutional mold and become disillusioned, inactive and apathetic. His efforts at modelling characteristics of the SEMT as described in this chapter have enabled him to circumvent the constraints arising directly from the institutional and managerial structures within his school. As an empowered mathematics teacher he has come to realize that he has in fact more scope for change than he would have previously acknowledged. His experiences of action-research, self- and peer appraisal together with other 'extended' professional activities have helped enormously to improve the quality of his own teaching situation. In the process, he has developed an essential strategy for overcoming the restraints on his power to act effectively and thus improve his mathematical functioning. His teaching has become more satisfying and fulfilled as he continues to internalize the gains of self-appraisal as a methodology by which to monitor the effect of bringing about purposeful changes to his teaching behaviour.

The formation of collegial relationships has been another significant and beneficial outcome emerging from many of the 'empowering' activities engaged in by the author. Characterized by openness and trust, this network of relationships with his mathematics colleagues has served to promote collaboration, co-operation, friendship and professional growth. It has provided significant pathways for communication for the mathematics teachers as a group in the school. The regular informal meetings dealing with important mathematics issues (the amended syllabi at
Junior cycle is one example) have helped to compensate in part for the lack of a structured mathematics department in the school. Heretofore, there was no tradition or model of such behaviour to which mathematics teachers could be responsive.

In recent years, this network of relationships has extended outside the environs of the author’s own school to include Ministry Inspectors (mathematics), third-level lecturers in mathematics education and industrialists. In the process, valuable insights and new perspectives have been gained. In short, the author would strongly suggest that SEMT’s, by establishing networks of collegial relationships to serve as a professional infrastructure, can do much to prevent apathy and stagnation from taking root.

Increased autonomy will help mathematics teachers realize that they do possess a valuable and specific competence relevant to problems in everyday life. SEMT’s are more likely to be perceived as ‘credible’ professionals as the activities they engage in help greatly to upgrade the core professional activity of mathematics teaching. Thus, the process of self-empowerment will enrich both the practitioner’s teaching and his self-esteem as a professional.

At a more general level, SEMT’s who have acquired coping skills and experience in self-appraisal will be better able to cope with stress and external pressures - in particular the fear of being held accountable with the impending arrival of teacher appraisal. By shifting the emphasis from the mere accumulation of facts to the development of actual skills and processes, SEMT’s will make a valuable contribution to implementing change in a technological society. Adaptable and flexible mathematics teachers are important considerations in an ever changing society. Finally, it is not extraneous to repeat that the
proactive qualities which empowered mathematics teachers will exhibit will provide pupils with a useful role model in coping with the demands of the information revolution. In addition, the role model can help contribute to the more general educational goal - that of helping students to learn how to learn.

At school level, there is the potential for a positive 'knock-on' effect. By assuming more control and responsibility for their work, task-directed groups of SEMT's can demonstrate to their colleagues the benefits to be gained from adopting a collegial approach to teaching and pedagogical matters of concern. Such a co-operative partnership and mutuality amongst mathematics teachers can help to reduce the isolation and 'closed door' syndrome so prevalent in Irish secondary schools. The collaborative nature of task-directed SEMT groups can help render key issues in school mathematics teaching and mathematics education in general problematic. In practice, these groups will suggest their own agendas, write their own action-plans, introduce, evaluate and reflect on their own experimental programmes with the aim of effecting an improvement. These issues will be tied to concerns which mathematics teachers believe are the really important ones, on matters such as classroom teaching, mutual observation, syllabus design and development or the practicalities of their working or institutional context. The creative process will generate new alternatives, possible responses and more innovative and self-determined mathematics teachers. Mathematics teachers by engaging in this form of empowerment will increasingly become aware that they have within their own experience a vast amount of data about learning, doing and teaching mathematics.

Through the process of deliberation, reflection, experimentation and evaluation, they will be in a position to unlock what is stored and subject it to scrutiny. This process of sharing insights and understandings can lead to
increased openness and trust among mathematics teachers as opposed to individualism and competition. In this fashion, the ‘self-renewing’ or ‘thinking’ mathematics department becomes possible, one which fosters many of the features shown by research to be desirable. This is important as the implementation of successful change in mathematics education in the future is likely to be critically dependent on an individual mathematics teacher’s capacity for growth and self-renewal and his ability to make a constructive and creative response to a rapidly changing environment. The ‘self-renewing’ mathematics department in turn provides an ideal model to encourage and foster systematic review, reflection and teacher professional development on a school-wide basis. Moreover the likelihood of SEMT group-activity becoming a viable proposition at the level of implementation appears high as it is the processes of schooling and not from outside agencies - of whatever kind - that teachers are most likely to find the motivation for and means of professional development [11].

At system level, the concept of SEMT’s merits close attention. A major improvement is envisaged in the whole area of teacher education and in-service education. By being introduced to the concept of self-empowerment at the pre-service stage, mathematics teachers will gradually appreciate its merits which will serve them well on a number of important counts during their teaching career. In-service education will be enhanced by the ability of SEMT’s to identify relevant training and developmental needs with the likelihood that such courses will become more school-based and school-focused.

Mathematics educators have for some time been faced with the problem of finding suitable processes by which mathematics curriculum proposals are turned into effective practice. The concern has been largely at the level of implementation at classroom level. The problem is
currently surfacing as an issue of major concern as Irish secondary schools prepare to implement the new *Junior Certificate Examination* (to replace the current Intermediate and Group Certificate examinations) from September 1989 for examination in 1992 [22]. In the mathematics context, the intention is to implement a new mathematics curriculum at three levels. Moreover, mathematics teachers and schools will be encouraged to become more confident in designing their own approaches to the curriculum and the confidence to take on school-based assessment. At a time when such a major curricular initiative is being proposed it is especially important to keep in mind the three mathematics curriculum levels:

- the intended (the prescribed mathematics syllabus)
- the implemented (that which mathematics teachers will teach)
- the attained (what students actually learn)

Currently, it is the new intended mathematics curriculum which is attracting most attention, with little or no indication of how these ideas are to be achieved at the level of implementation. Yet syllabus design cannot be successfully implemented without due consideration being given to ensuring that great discrepancies and divergences will not arise between the intended and the implemented mathematics curriculum. The empowerment process offers the Irish Ministry of Education a strategy by which their intended rhetoric can be matched by effective practice in reality. As autonomous agents in the practical business of mathematics curriculum development, SEMT's will possess the competence and skills to make the transition from intended to implemented mathematics curriculum and ensure that what is taught is closely linked to what can be learned.

Irish secondary mathematics teachers do not take an active role in assisting curriculum developers in improving
mathematics education by formulating designs and demands. This was evidenced in the very low number of submissions received from practising mathematics teachers during the recent revision of the Intermediate Certificate mathematics courses.

The author’s response on this latter issue culminated in a written submission (Appendix 0) to the then Curriculum and Examinations Board (now the NCCA) as he wished to participate in an important decision that would affect his future teaching. This is further testimony to the author’s desire and willingness to contribute to important issues in secondary mathematics education.

Thus, the concept of the self-empowered mathematics teacher implies that in the future reconstruction of mathematics curricula, curriculum developers will have available to them the collective insights and inputs from groups of empowered mathematics teachers which engage in iterative 'planning-experimentation-evaluation' cycles. It is fair to conclude that such informed decision-making which takes the perceptions and concerns of mathematics teachers into account provides a more valid basis for the improvement of pedagogy, teaching performance and mathematical education in general.

At a more general level, improvements in mathematics will occur as a consequence of systematic analysis of teaching and exploration of alternative approaches. A new analysis of the fundamental role of mathematics in the secondary school curriculum will be achieved, one which takes cognizance of pupil abilities and the implications of a technological society. This will be facilitated by groups of empowered mathematics teachers giving serious consideration to major issues concerning the future of secondary school mathematics: the problem of arriving at a comprehensive set of mathematical aims and objectives, the balance between content and process, the intellectual
worth of learning mathematics, the extent to which it should be compulsory for all, the problems of differentiation and of drop-out and how it may both reflect and contribute to the Irish culture. Only by this more fundamental reappraisal will Irish secondary school mathematics facilitate the justification and place of mathematics and thereby more effectively serve the future needs of society.

The profile of the self-empowered mathematics teacher presented in this chapter together with the ensuing consequences and benefits are summarized in Figure 14 which offers a functional model of the 'self-empowered' mathematics teacher.

Throughout this chapter the author has presented to the reader various interventions from his own teaching situation which illustrate the concept of the SEMT in reality. Individually, these examples might appear unremarkable but collectively they provide evidence that give practical realization and credence to the notion of empowerment as a worthwhile process for secondary mathematics teachers.

It is necessary in conclusion to reiterate that the onus should not be on mathematics teachers to become self-empowered without the accompaniment of professional support and incentives from both the Irish Ministry of Education and Schools.
AIM
Competent mathematics teachers who are self-managing, self-directing, in control and who make informed decisions

METHODS
Learning appropriate skills
Being more aware of their own strengths
Finding information through classroom research
Informed decision-making
Clarifying values
Iterative 'Deliberation - Experimentation and Evaluation' Cycles
Searching for meaning in practice through reflection and experimentation
Productive Task-Directed Group Work

RESULTS
Proactive mathematics teachers
Liberation from manipulation and external control
Less isolation and increased collaboration, increased autonomy
Increased awareness, confidence and self-understanding
Improved in-service based on teacher needs
The self-renewing mathematics department
Provision of a useful role model for pupils in a technological society
Enhanced professional development, improved pedagogy and more effective teaching
Fundamental reappraisal of key mathematical issues

Figure 14: A functional model of the self-empowered mathematics teacher
CHAPTER 11

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND IMPLICATIONS FOR FURTHER RESEARCH

In this, the concluding Chapter of the thesis, the author proposes to set out conclusions which derive from the research already completed. Appraisal, as a key issue in school mathematics education in Ireland, formed a major focus of this study. Major conclusions are derived therefore from considerations arising from Chapters 7 and 8 which encapsulates all previously related work on appraisal. Further conclusions and recommendations, arising from the the empowerment ideology (Chapters 9 and 10) together with outcomes of the early chapters, are then articulated by the author.

11.1 Appraisal and School Mathematics Education:
Conclusions and Recommendations

The research work on appraisal, as contained in Chapters 7 and 8, describes in some detail the author's attempt to follow through the implications of what for him is an important insight into school mathematics. It concerns appraisal, accountability, professionalism and pedagogy in school mathematics education. Appraisal is investigated specifically from the point of view of secondary mathematics teachers working in a particular context, namely the Irish education system. An attempt has been made to customize the process for mathematics teachers and
at the same time address the demand for wider accountability in a national context. The research exercise generated the following outcomes:

(1) a model for effective mathematics teaching
(11) a positive rationale for the introduction of appraisal
(111) appraisal techniques for mathematics teachers
    - a self-evaluation instrument for self-appraisal
    - a collegial technique for peer appraisal
    - an appraisal instrument for use by pupils
    - audio and video techniques for self/peer appraisal
(IV) a model for a national system of appraisal
(V) strategies for successful appraisal
(VI) insights arising from subjecting the above ideas and models to a limited amount of 'expert' scrutiny.

The systematic testing of the above techniques and models by means of field trials or pilot studies is an area where further research is needed. In this connection, mathematics teachers must play an active and participative role. The ultimate conclusion is that the exercise was worthwhile as a contribution to the educational debate as it focuses attention on an important issue which mathematics teachers and educational administrators are already anticipating in Ireland.

More specifically, the aforementioned research outcomes have prompted the author to postulate the following conclusions which are set out as principles for future consideration and action. These principles are followed by relevant and considered recommendations where appropriate.

Informal appraisal is widespread but unsatisfactory. An agreed effective system offers an alternative. A fundamental issue in the design of any appraisal scheme is that of purpose(s). The overriding consideration in this regard for secondary mathematics teachers must be to
improve current performance by motivating mathematics teachers towards better practices through self-development. In this connection the conclusion is:

**Principle 1**: The primary purpose of appraisal ought to be developmental: to improve teacher effectiveness through improved performance and pedagogy in mathematics teaching.

The existing practice of mathematics teachers cannot be improved if the reality of that practice is not analyzed and acknowledged. In this regard appraisal confers a number of significant advantages:

- reduction in stress and anxiety
- adaptability in a rapidly changing world
- enhanced professional development
- training needs are identified and met
- improved pedagogy and classroom performance.

In conjunction with the empowerment ideology, the author concludes that:

**Principle 2**: Appraisal has several positive advantages for individual mathematics teachers, groups of mathematics teachers, individual and groups of schools and for society in general.

**Recommendation**: In order to promote the principle that the process of appraisal is a valuable one, an initial programme of re-education is required for mathematics teachers, Headteachers, parents, politicians and society in general.

Mathematics teachers will have natural suspicions and fundamental psychological fears regarding formal appraisal. They will be averse to hierarchical and superi ate methods of appraisal.

**Principle 3**: In order to overcome suspicions and genuine concerns the appraisal process needs to be introduced into schools sensitively and carefully.

**Recommendations**: Videos of capable and effective mathematics teachers need to be produced and made available as a resource aid for private self-study and observation by those mathematics teachers who have been identified as in need of support and help. Further research is needed to develop, produce and test the
effectiveness of such videos as an aid towards the improvement of mathematics teaching.

Appraisal is likely to lead to demands for visits to other schools to see experienced mathematics teachers teaching particular topics or perhaps to view a particular teaching method. In this connection, the author recommends a new emphasis on increased collaboration and co-operation between schools in the area of reciprocal peer appraisal. This can help allay the psychological fear of having to reveal and expose 'weaknesses' within one's own school. One consequence of this might well be the identification of 'lighthouse' or 'magnet' schools, modest centers of excellence whose mathematics teachers could be emulated.

One consequence of increased standards of performance will be a demand for greater reward, related to an individual's worth to the school. Positive incentives might include improved opportunities to obtain academic and professional qualifications. It could take the form of support and encouragement for mathematics teachers who, as a result of appraisal, implement new ideas in their schools. Sabbatical leave or teacher fellowships on a paid leave basis could provide the means by which these incentives could be realized.

The next principle relates to guidelines for the design, development and implementation of appraisal schemes.

Principle 4 : Extensive consultation on the design and implementation of a formal appraisal scheme is necessary to promote a sense of ownership and commitment to the process. Power-coercive strategies must be avoided and monitoring is essential to evaluate the effectiveness of a formal appraisal scheme.

Recommendations : To ensure a specific mathematics education interest in the design of appraisal schemes, the author recommends the establishment of a National Advisory Body on the Teaching of Mathematics to help co-ordinate inputs from mathematics teachers at regional and local level. The 'appraisal' functions of such a Body ought to include:

- to actively seek and co-ordinate inputs from mathematics teachers during the design and piloting of appraisal schemes

1. In an unofficial way this was a key form of curriculum development in Ireland during the 1970's although admittedly, such schools were created ab initio and not spotted and brought to general attention.
- to play an active role in the development and piloting of appraisal instruments specifically for mathematics teachers
- to keep abreast of developments in theory and practice
- to make recommendations when necessary to the Ministry of Education on matters affecting mathematics teaching.

On the issue of moderating procedures, a mathematics teacher in one school may be more effective in another. Accordingly, at a time when redeployment is becoming operative in Irish secondary schools, the author recommends that the management aspect of an appraisal system would be met in part if mathematics teachers were enabled to transfer to schools in which their talents would be better used.

Without adequate resources, appraisal will fail. The volume of resources needs to be such that mathematics teachers see that appraisal will work in a positive way to improve their effectiveness as teachers. Thus:

Principle 5 : The introduction of a systematic system of appraisal will require time, finance, materials, central administration, release time for teachers, secretarial costs and a comprehensive training programme for all partners involved.

Recommendation : Formal appraisal skills are unlikely to be acquired other than through a process of training involving the use of practice interviews on closed circuit television, role-playing and other similar techniques. To this end, the author recommends that educational videos be commissioned and produced which show appraisal interviews being effected by experienced senior appraisers.

The next principle emphasizes that appraisal ought not to be isolated from other school processes.

Principle 6 : Appraisal ought to be linked to the significant and fundamental process of whole-school staff development and to in-school review and evaluation procedures. This requires knowledge of management education.

Recommendation : A significant new impetus is required in the area of management education if appraisal is to succeed at school level in Ireland. To this end the author recommends that the Department of Education provide pump priming funds for the establishment of a National Central Staff Development and Management Training Centre.
to be run by a steering committee representing management interests and the Department of Education. Such a venture could assist in introducing and sustaining successful appraisal by:

- the development of appraisal skills, especially management process skills and skills in group dynamics, by the provision of initial and refresher management development programmes for mathematics teachers, senior staff and Headteachers
- the provision of annual compulsory courses for aspiring principals and vice-principals
- fostering the concept of a Staff Review Committee as an aid in monitoring appraisal at school level
- encouraging Irish Universities to expand their M.Ed. courses in educational management
- generally arguing for increased staff development activity.

Assessing teacher effectiveness and current performance in mathematics education is problematic and demands careful attention.

Principle 7: Appraisal must take cognizance of the pedagogical knowledge of mathematics teachers and research into effective mathematics teaching.

Recommendation: Further research is required on the issue of effective mathematics teaching. The author's model laid stress on certain teacher attributes and the significance of management process skills. These merit further consideration together with an investigation of how mathematics teachers can best acquire these skills.

The author's model for effective mathematics teaching also drew attention to the central role of self-appraisal in promoting teacher effectiveness. Together with peer appraisal these processes have much to offer.

Principle 8: As sources of data about teaching performance self-appraisal and peer appraisal ought to play a role in full formal appraisal.

Recommendation: As both self/peer appraisal requires a mathematics teacher to become aware of the consequences of his actions by reflecting about his practice then it follows that there is an urgent need to include time for thinking, deliberation and in-service education as part of a teacher's normal working week. This has important
implications for how teachers are trained and educated. Teacher education courses for mathematics teachers should include courses which involve a pedagogy embracing reflection, encouraging student teachers to place a high premium on the knowledge they gain from experience and classroom research and one which recognizes the role that collegiality with peers has towards the improvement of children's learning. These are not common undergraduate experiences at present. One cannot expect mathematics teachers to take on such a process as appraisal if they are trained to conform to established practice.

Notwithstanding the benefits which self/peer appraisal confers, both processes would lack credibility as major sources of data for performance appraisal and are unlikely to find official support as viable alternatives to formal appraisal. A national system of formal appraisal can have an uplifting effect upon the climate and quality of secondary education.

**Principle 9 : A national system of formal appraisal is necessary.** This ought to include:

- self-appraisal ('bottom-up' aspect)
- peer appraisal ('sideways' aspect)
- formal appraisal of all teachers ('top-down' aspect)
- formal appraisal of Headteachers
- a role for parents and pupils
- an appeals and monitoring procedure.

**Recommendations :** Formal appraisal of its very nature demands a comprehensive back-up service for mathematics teachers. It is essential that such structures be created to provide the necessary support on an on-going basis. Accordingly the author proposes:

1. The appointment of mathematical advisers by the Irish Ministry of Education to encourage and support mathematics teachers in meeting the challenge posed by appraisal. This proposition appears viable in the current climate of teacher redeployment as suitable existing mathematics teachers could be retrained to take on this essential facilitative role.

2. The creation of a centre for research in mathematics education. The IREM's in France, the CAGET and Shell Centres in England or those at the Universities of Georgia and Wisconsin in the...
U.S.A. provide source models. In the appraisal context, the functions of such a research centre could be:

- to develop appropriate appraisal instruments for mathematics teachers
- to initiate and co-ordinate pilot appraisal schemes involving mathematics teachers
- to commission and produce distance learning materials, for example, educational videos as recommended earlier in liaison with the proposed National Central Staff Development and Management Training Centre
- to disseminate best practice in relation to mathematics teaching by establishing data pools
- to act as a national agent in the planning, co-ordination and teaching of necessary in-service courses for secondary mathematics teachers
- to co-ordinate the mediation and interpretation of meaning among the community of mathematics teachers within the current highly centralized system of post-primary education.

The impact of Irish Ministry of Education Inspectors on the monitoring of secondary mathematics teaching is virtually zero. Moreover current Irish educational structures do not facilitate the introduction of successful appraisal as evidenced by the replies from the limited 'expert' evaluation.

Principle 10: The role and function of the inspectorate needs a re-definition. In addition, the introduction of formal appraisal implies the re-organization of current Irish educational structures.

Recommendations: The Irish Ministry of Education needs to re-educate existing qualified personnel for their new role and take the necessary steps to induct new expert personnel into their ranks. The new role for mathematics Inspectors could include:

- a contribution in the design of appraisal instruments for mathematics teachers
- assisting in the training of mathematics teachers for appraisal
- engaging in the formal appraisal of Headteachers.

At structural level, the author recommends the establishment of agreed local education authorities to facilitate the introduction of meaningful appraisal.
General Recommendation: No mention has been made of the financial implications posed by the aforementioned recommendations. Financial resources on an appropriate scale are essential if these are to be realized. The author is aware, that with reduced finances, attempts to introduce appraisal will be counter-productive. In Ireland, the monies on the scale required can be secured only from central government. Other parties ought also to make a contribution. Large industrial and commercial interests are consumers of education and are currently benefiting from favourable conditions in the Irish economy. Such firms, whether large or small, public or private ought to contribute to an Education Trust Fund and in return receive tax refunds. The accumulated subscriptions (however modest) of many companies will assist central government in the implementation of necessary action plans.

It is the author's conviction that the desired improvement in school mathematics through better pedagogy will be achieved by implementing appraisal for mathematics teachers in a form which seeks to develop the professionalism of individual mathematics teachers. Self-appraisal is an essential stage in this process and is viewed as a means of maximizing potential benefits. It is gratifying to note that the concept of self-appraisal which the author has propounded has found recent favour with the largest post-primary teachers' union [190]. In this context of enrichment, empowerment and professional support these concerns have a universal appeal which transcends the country 'case-study' aspect. Insofar as the research described here achieves this end, a small contribution has been made by the author to the literature in mathematical education. Appraisal is under the spotlight and it is essential that mathematics teachers prepare for its inevitable arrival in a positive fashion. If mathematics teachers do not take up the challenge and grasp the initiative to at least formulate the right questions on the direction of appraisal in the near future, others less qualified and less concerned may supply the wrong answers which could lead to a narrowing rather than a widening of opportunities in mathematics education.
11.2  Empowerment and Additional Key Issues: Further Recommendations

The historical survey presented in Chapter 2 provided a backdrop for the identification of additional key issues in Irish secondary school mathematics education. These are summarized below:

1. the place and aims of secondary school mathematics
2. the depowering professional position of the secondary school mathematics teacher
3. the mathematics curriculum and teaching:
   - the need for alternatives to the current 'compartmentalised-linear-compulsory' mathematics curriculum
   - the failure of 'content' orientated differentiation strategies to provide relevant mathematics courses for the majority of pupils
   - the failure to appreciate the role of new technology for mathematics teaching
   - the distorting influence of universities and examinations on mathematics teaching.

The elucidation and analysis of these issues was achieved in Chapter 3. Possible avenues for the future were explored and implications highlighted. The reader is referred to Chapter 3 for an elaboration of these specific recommendations. In this regard, the 'modular' curriculum and the suggestions made for a restructuring of the mathematics curriculum on the basis of applications merit further research.

The previous section noted that appraisal contributes to the professional position, development and status of mathematics teachers. Moreover, the case for, and the profile of, the self-empowered mathematics teacher as argued and presented in Chapters 9 and 10 offers a conceptual and practical strategy for a deliberative and problem-solving approach to key issues in Irish school
mathematics education. The empowerment ideology seeks to invest mathematics teachers with a capacity to re-appraise their own practice and subject the ideological and institutional context of their working reality to scrutiny. In arriving at a new and important synthesis between empowerment and appraisal the author argued that it offered a means of rendering key issues in school mathematics education problematic as in the empowering potential of:

- training and practice in self-monitoring skills
- rendering teaching and how to teach problematic
- the deliberation-experimentation cycle
- the development of professional autonomy in curricular issues through task-directed groups.

Accordingly, what the author proposes is to displace a current ideology based on subservience and acquiescence by a more dynamic and empowering ideology which attempts to hand back a degree of control to mathematics teachers. The promotion of ideologies is not a new development. What is new is the conscious effort to promote ideological thinking as a means of improving the professional development, pedagogy and teaching performance of secondary mathematics teachers in Ireland.

In the previous chapter, the author suggested that self-empowered mathematics teachers would be suitable candidates to take on an important role as mathematics coordinators in secondary schools. His duties could include:

- the provision of guidance and support to other mathematics teachers in implementing the school mathematics plan.
- helping new mathematics teachers by informing them about the mathematics courses, textbooks and available teaching aids
- promoting school-based curriculum development in mathematics with special consideration for pupils with particular needs
- reviewing, organizing and selecting mathematics textbooks, resources and teaching materials in conjunction with colleagues
- keeping colleagues up-to-date with recent research and development in mathematics
- maintaining contact with primary schools with a view to ensuring curriculum continuity between primary and post-primary school mathematics
- co-ordinating and relating work which takes place in the computer laboratory to that in the mathematics classroom.

Many of the recommendations made in the early part of this chapter are also applicable in promoting and fostering the concept of self-empowerment at 'grassroots' level among secondary mathematics teachers. In particular, the National Centre for Research in Mathematics Education in conjunction with the National Staff Development and Training Centre (both recommended earlier) can do much by the production of professional distance learning materials including educational videos which portray various dimensions of the self-empowered mathematics teacher. Admittedly, the ideal profile will not be possible to achieve but videos could demonstrate capable and effective mathematics teachers or groups of empowered mathematics teachers engaged in productive task-directed work. Mathematical advisers could also assist individual mathematics teachers to aspire to the level of empowerment.

It is fair to conclude that the synthesis of appraisal and empowerment, if instituted with the necessary support structures, offers a possible solution to some significant problems in Irish school mathematics education by:

- the provision of a public accountability mechanism
- more effective mathematics teaching including a new awareness of the potential of technology for enhancing mathematics teaching
- increased control by mathematics teachers over teaching and curricular matters
- improved opportunities for in-service education
- enhanced personal and professional development
- the generation of alternatives to the current compartmentalised and 'content-orientated' mathematics curriculum
- rendering key issues in school mathematics
education problematic
- ensuring a smooth transition from the intended to the implemented mathematics curriculum.

Other important 'knock-on' effects include a contribution to general educational goals and the provision of a useful role model for pupils. Finally, the promotion of the empowered or 'self-renewing' mathematics department provides an ideal model for systematic review and analysis on a school-wide basis.

All of the recommendations suggested by the author in this Chapter must take cognizance of the central authority in education, namely, the Irish Ministry of Education. Without the active support and commitment from this central authority in education no recommendations or plans for future action can succeed, no matter how desirable or important these might be. In the context of the key issues enunciated at the outset of this section the author makes the following specific recommendations. The Irish Ministry of Education ought to:

1. continue its fundamental re-appraisal of the secondary school mathematics curriculum begun by the Curriculum and Examinations Board with a view to:

   - arriving at a more comprehensive and defensible set of mathematical aims and objectives for secondary school mathematics
   - developing and piloting viable alternatives to the current compartmentalised mathematics curriculum to meet the needs of the majority of pupils
   - alleviating the current 'profit-pleasure' imbalance in mathematics teaching
   - meeting the needs of those who 'drop out' early
   - instituting a national initiative in the area of information technology as proposed by Moynihan et al [77]
   - implementing the Pupil Transfer Report [61] recommendations to help alleviate existing 'alignment' problems between primary and secondary school mathematics curricula
   - reducing the determining influence of Irish universities on the mathematics curriculum. This
could be achieved by a programme of re-education aimed at parents, pupils, teachers, politicians and employers. Irish universities ought also to be encouraged to become more closely involved with secondary mathematics teachers - individuals or groups - in the form of school-based studies.

2. promote a new concept of professionalism among mathematics teachers by:

- actively promoting and fostering the concept of the self-empowered mathematics teacher
- providing incentives for mathematics teachers to engage in innovative research work at national, regional and school level
- insisting on the formal introduction of self-empowered mathematics departments in all secondary schools as an appropriate professional unit
- appointing mathematical advisers
- establishing a research center for mathematical education as recommended earlier
- insisting on adequate standards and qualifications for all mathematics teachers
- providing opportunities for mathematics teachers to extend their initial qualifications
- giving serving mathematics teachers a role in the accreditation of pre-service teacher education courses
- instituting a proper promotional and career structure to attract and keep mathematics graduates of highest calibre.

3. insist that mathematics teacher training institutions incorporate a new redesigned pedagogy where self-empowerment and the urgent need for reflection command higher status.

4. in conjunction with the National Council for Curriculum and Assessment (formerly the Curriculum and Examinations Board) give serious consideration to the merit of empowerment as an intervention strategy in secondary mathematics education. In this connection, the new Junior Certificate mathematics curriculum proposals could be more easily turned into effective practice and divergences between the intended and implemented mathematics curriculum prevented.
11.3 Further Research

The outcomes of this study have raised new questions and dimensions which are beyond the scope of this thesis to consider. The author now addresses a number of these dimensions as a pointer towards future needs and directions for change.

This thesis has been largely concerned with answering the question: 'what changes are required in school mathematics as a result of research into key school mathematics education issues?' Further research is needed to address and answer the question: 'how are such changes to be implemented?' Although the author has suggested that the partial answer lies in adopting and implementing the empowerment strategy as one means of intervention by which changes are turned into effective practice further research is needed in this crucial area. Knowledge of how to achieve desired changes in school mathematics education is scant; of the way in which the processes of change are generated; of the speed at which schools and individual mathematics teachers adapt to change; of the relative merits of the various strategies propounded by the author for achieving successful appraisal. Yet, appraisal, for example, will hinge on the successful implementation of new strategies, new conceptions, new visions. What techniques are effective in persuading mathematics teachers to change their long-established habits and beliefs, and to adopt new teaching or appraisal techniques with which mathematics teachers may be unfamiliar? What are the conditions which cause mathematics teachers to close up, be unadventurous and thus prevent them from implementing desired changes in practice? All of these questions merit serious consideration in the near future.

The pilot study in Chapter 4 suggested that pupils' views concerning the mathematics education they receive should
not be ignored. The study revealed that the aesthetic and 'pleasure' aspects of mathematics are not being taught nor are pupils able to transfer mathematical knowledge gained in one topic to others. The emotive feelings and comments elicited suggested strong pupil disenchantment with current mathematics courses. Admittedly, the applicability of these findings is limited by the size of the study. Further research is required to answer additional questions. Will a trend towards more open-ended investigations in the mathematics classroom enable more students to have a first hand experience of the aesthetic rewards that mathematics affords? To what extent can a certain topic trigger a positive or negative chain reaction to a pupil's general attitude to mathematics? How can mathematics teachers be assisted to help students appreciate the power and role of mathematics at the level which pupils have reached? How can pupil opinions be productively channelled during the negotiation of changes in the school mathematics curriculum? How is a technological environment affecting students' perceptions of desirable mathematical knowledge?

In Ireland, concern has been expressed for some time in regard to the low level of research in mathematical education [4]. The minuscule amount of money spent in this area is regrettable considering the huge proportion of the national budget which the education system devours. In general, it must be assumed that valuable research in mathematics education is much more likely to be done by trained 'career' researchers. In this context, the center for research in mathematical education recommended earlier will have a central role to play. However further research is needed to evaluate the concept of the 'teacher-researcher' as a viable proposition. In this regard, the author has laid a foundation for 'practitioner' and school-based research in mathematics education as evidenced by this thesis. The limitations of such research have already been treated at length by the
author in Chapter 4 together with suggesting means of enhancing the generality and applicability of such studies. The author would state that his naturalistic and illuminative research work has enriched, empowered and improved both his teaching and self-esteem as a professional. In making a case for the 'reflective practitioner' it has not been the author's intention to establish a dichotomy between 'career' and 'teacher' researchers. On the contrary, an important area for further research is: 'how can teams of teachers and researchers be organized to address research problems of mutual interest and concern and what techniques are effective in sustaining the operation of such teams?'

In conclusion, the above matters are considered significant and relevant in the context of mathematics education in Ireland. This thesis would strongly suggest, that when looking ahead, it must never be assumed that mathematics teachers have no role to play in analyzing their own situation and finding a means of change. It is the 'lighthouse' mathematics teacher who can indicate the way ahead for successful large-scale developments by demonstrating what is possible in his own classroom. Changes based on experience have a greater chance of success than those based on hunches and pipe-dreams.
REFERENCES


[12] Personal correspondence to the author in November, 1985, by Mr. Sean Cronin, ASTI representative on the then mathematics syllabus committee.


[23] Issues and Structures in Education : A


[27] Irish Independent, April 5th, 1988.


[37] Personal correspondence to the author in May 1985, by Mr. Fred Holland, secondary mathematics teacher who was a teacher representative on the early mathematics syllabus committees.


[40] Personal correspondence to the author in May 1985 by Fr. B.P. Steen, Head of Mathematics, St. Patrick's Training College, Dublin. (Fr. Steen was also a member of the early mathematics syllabus committees)


Patrick’s Training College, Dublin.

[47] An evaluation of I.M.U. in Irish secondary schools, undated and source of publication not stated. The author is grateful to Mr. P. Crowley, Department of Education (Psychological Service), Cork for lending him a rare copy.


[67] Reply to a questionnaire (see Chapter 7) by a secondary school mathematics inspector, March, 1988.


[71] ASTIR, April, 1985.


[80] Association of Secondary School Teachers of Ireland (ASTI), 1980, Submission to review body on teachers' pay, Dublin.


[82] Elliott, J., 1983, "Self-evaluation: professional development and accountability", ...


[96] Irish Independent, August 5th, 1986.


The Coleraine Questionnaire for Attitudes to Mathematics, in Connolly, J., 1975, The attitude of girls to mathematics in selected schools in Northern Ireland, unpublished Diploma in Advanced Studies in Education, University of Ulster at Coleraine.


The National Union of Teachers, 1985, Teacher Appraisal and Teaching Quality, London.


[144] Fletcher, T.J., 1975, "Is the teacher of mathematics a mathematician or not?", Schriftenreihe des IDM, Universitat Bielefeld, No. 6, 20318.


Bunnell, S. and Stephens, E., 1984, "Teacher


APPENDIX A

REVISED SYLLABI IN MATHEMATICS, JUNIOR CYCLE, IRISH POST-PRIMARY SCHOOLS
PREAMBLE

The underlying philosophy of the syllabuses points to Mathematics as a human activity rather than a ready made subject. It emphasises the practical experiences of the pupil from which the Mathematics is extracted. It searches for relations rather than isolated phenomena and uses rich contexts rather than collections of word problems. Above all it works towards understanding rather than skill.

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. While working through the programme the pupil 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;
- apply Mathematics to problems 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.

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, depending on the circumstances of the particular class.

Note 2: It is recommended that reference be made where appropriate to the history of Mathematics and to the lives of great mathematicians.
INTERMEDIATE CERTIFICATE
MATHEMATICS
SYLLABUS A

SECTION ONE

SETS

RELATIONS AND FUNCTIONS
Couples. Use of arrow diagrams. Domain, codomain, range, Function as a special relation.

NATURAL NUMBERS

INTEGERS
The set Z. Order (<, ≤, ≥, >). +, -, x, ÷ in Z. Use of arrow diagrams to illustrate order relations. Use of number line to illustrate the relations +a, -a, xa for a∈Z.

RATIONAL NUMBERS
The set Q. Decimals, fractions, percentages. +, - , x, ÷ in Q. Rounding off to not more than three decimal places. The practice of approximating before evaluating. Ratio and proportion. Decimals and fractions plotted on the number line.

REAL NUMBERS
Every point on the number line represents a real number. Solving linear inequalities in one variable (e.g. 2x - 1 ≤ 9) and graphing the solution set on the number line.

MEASURE

ALGEBRAIC EXPRESSIONS
Meaning of variable, constant, term, expression, coefficient. Evaluation. 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). 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) ÷ (x+3), (6x^2 +x-12) ÷ (3x-4), (6x^3-x^2-33x-28) ÷ (3x+4).
Formation and interpretation of number sentences leading to the solution of first degree equations in one variable.

Use of square, square root and reciprocal tables p.20 to p.27.

It can be assumed that

(i) Two triangles are congruent if two sides and the included angle in one are equal in measure, respectively, to two sides and the included angle in the other.

(ii) Two triangles are congruent if two angles and a side in one are equal in measure, respectively, to two angles and a corresponding side in the other.

Vertically opposite angles are equal in measure.

The three angles of a triangle sum to 180°.

The external angle of a triangle is equal in measure to the sum of the two interior opposite angles.

The opposite angles and the opposite sides of a parallelogram are equal in measure.

The angles at the base of an isosceles triangle are equal in measure.


Cartesian product of two sets. Composition of relations. Inverse of a function. Coordinating the plane. Drawing graphs of functions \( f: x \rightarrow f(x) \), where \( f(x) \) is of the form \( 3x + 4 \) or \( x^2 - 5x + 6 \).

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

Rational numbers expressed as decimals. Terminating decimals expressed as fractions. Expressing a non-terminating repeating decimal in rational form. Scientific Notation.
Interest added at regular intervals to a maximum of three (formula not required).

Length and area of circle. Surface areas and volumes of cylinder, cone and sphere. Application using the Theorem of Pythagoras.

Cosine, sine and tangent of angles. Values of these functions for $0^\circ$, $30^\circ$, $45^\circ$, $60^\circ$, $90^\circ$, $180^\circ$, $270^\circ$, $360^\circ$, where defined.

Factors of expressions such as $6xy + 3y^2$, $ax - by + bx - ay$, $ax^2 + bx + c$, $x^3 - 4y^2$, $x^3 - y^3$, $x + y^3$.

Solution of quadratic equations of form $ax^2 + bx + c = 0$ using factors.

Drawing and interpreting bar-charts, pie-charts, trend graphs, histograms. Discrete array expressed as a frequency table. Mean and mode. Cumulative frequency. Ogive, median, interquartile range. Mean of grouped frequency distribution.

Show how to construct the midpoint of a given line segment. Use of instruments to draw a perpendicular to a given line segment through a given point.

Coordinates of the images of points under translation, axial symmetry, central symmetry and parallel projection. Distance. Midpoint. Area of triangle.

The image of a point $x$ under the axial symmetry in the line $L$ is $y$ if $xy \perp L$ and $L$ bisects $[xy]$.

The image of a point $x$ under the central symmetry in the point $k$ is $y$ if $k$ is the midpoint of $[x \ y]$.

The image of a point $x$ under the translation $ab$ is $y$ if $x \ y b$ is a parallelogram.
The image of a point $x$ under the projection on $L$ where the projection is parallel to $K$ is $y$ if $y \in L$ and $xy \parallel L$.

Use of set squares and compass to find the image of a set under a transformation $f: x \rightarrow f(x)$ and to verify

(i) that a rotation is the composition of two symmetries in non-disjoint axes

(ii) that two axial symmetries in perpendicular axes is a central symmetry

(iii) that two axial symmetries in parallel axes is a translation

(iv) that two central symmetries is a translation

(v) that two translations is a translation.

Every point on the perpendicular bisector of a given line segment is equidistant from the end points of the line segment.

Construct with proof, the circumcentre of a given triangle.

Construct, with proof, the bisector of a given angle.

Any point on the bisector of an angle is equidistant from the arms of the angle.

Construct, with proof, the incentre of a given triangle.

The image of a circle under the axial symmetry in a line through its centre is the same circle.

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.

A line is a tangent to a circle at a point $t$ on the circle if it is perpendicular to the diameter through $t$. 
SECTION THREE

FUNCTIONS
Maximum and minimum value of quadratic function found graphically. Solution of a quadratic inequality found from the graph of a quadratic function, the solution being given in the form \( a \leq x \leq b \).

EQUATIONS
Quadratic equations of the form \( ax^2 + bx + c = 0 \) for real roots only.

ALGEBRAIC EXPRESSIONS
Rearrangement of formulae. Addition and subtraction of algebraic expressions such as \( \frac{a}{b(x+c)} + \frac{p}{qx + r} \) for \( a, b, c, p, q, r \in \mathbb{Z} \).

INDICES AND LOGARITHMS
\( \log_c a = x \Rightarrow a = c^x \).

Justification of the following rules:
(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) \( \log_c a = \log_{10} a / \log_{10} c \)

Numerical applications such as \( \log_c 24 \) expressed in terms of \( \log_c 2 \) and \( \log_c 3 \).

Arithmetic operations applied to \( a + \sqrt{b} \) where \( a, b \in \mathbb{Q}^+ \).

TRIGONOMETRY
Reading trigonometrical tables.
Solving right angled triangle problems.
Area of triangle. Sine rule and applications.

COORDINATE GEOMETRY
Slope of a line. Parallel \( (m_1 = m_2) \) and perpendicular \( (m_1 m_2 = -1) \) lines.

Equation of line in the two forms \( y = mx + c \) and \( y - y_1 = m(x - x_1) \).
Intersection of lines. Equation of the image of a line under a translation.

CONSTRUCTION
To divide, with proof, a line segment into a given number of parts of equal length.

THEOREM
A line drawn parallel to one side of a triangle divides the other two sides in the same ratio.

THEOREM
If the angles of two triangles are, respectively, equal in measure, then the lengths of the corresponding sides are proportional.
THEOREM

If \([ab]\) and \([cd]\) are two chords of a circle intersecting in \(k\), then
\[
|ak| \cdot |kb| = |ck| \cdot |kd|.
\]

COROLLARY

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
\[
|pa| \cdot |pb| = |pt|^2.
\]

THEOREM

In a right angled triangle the area of the square on the hypotenuse is the sum of the areas of the squares on the other two sides.
SETS

RELATIONS
Couples. Use of arrow diagrams.

NATURAL NUMBERS
The set \( \mathbb{N} \). Place value. Sets of divisors. Pairs of factors. Recognition of prime numbers. Sets of multiples. Lowest common multiple. Cardinal number of a set. +, −, \( \times \), ÷ in \( \mathbb{N} \). Approximate answers. Commutative property. Meaning of \( a^n \) for \( a, n \in \mathbb{N}, n \neq 0 \).

INTEGERS
The set \( \mathbb{Z} \). Order \( (\prec, \preceq, \succ, \succeq) \). +, −, \( \times \), ÷ in \( \mathbb{Z} \). Use of arrow diagrams to illustrate order relations. Graphing \( 2 \leq x \leq 7 \), say, on the number line.

RATIONAL NUMBERS
The set \( \mathbb{Q} \). Decimals, fractions, percentages. +, −, \( \times \), ÷ in \( \mathbb{Q} \). Rounding off to not more than three decimal places. The practice of approximating before evaluating. Ratio and proportion. Decimals and fractions plotted on the number line.

REAL NUMBERS
Idea that every point in the number line represents a real number. Solving linear inequalities in one variable (e.g. \( 2x - 1 \leq 9 \)) and graphing the solution set on the number line.

MEASURE

MONEY

ALGEBRAIC EXPRESSIONS
Meaning of variable, constant, term, expression, coefficient. Evaluation. Addition and subtraction of simple algebraic expressions such as:
\[
(2x+3) + (4x-2), \quad (3x+2y) - (x+3y-4), \\
(5x^2+7x-2) + (2x^2 -x-7).
\]

EQUATIONS
Graphing on the number line the solution set of simple first degree equations in one variable.
CONSTRUCTION

Use a ruler, compass, set squares, protractor to draw and measure line segments and angles and to construct squares, rectangles and triangles from given data. Straight angle measures 180°.

PROPERTIES

Use of construction to establish intuitively the simple properties of square, rectangle and parallelogram e.g. (i) equality of lengths of opposite sides and measures of opposite angles, (ii) comparing the lengths of diagonals and the measures of the angles between them.

PARALLELOGRAM

Construct parallelograms given the measure of:
(i) two adjacent sides and included angle
(ii) two adjacent sides
(iii) one side.

SECTION TWO

SETS

Set operations: difference, complement.
Set operations extended to three sets.

RELATIONS AND FUNCTIONS

Domain and range. Function as a special relation.

ALGEBRAIC EXPRESSIONS

Use of distributive property in the removal of brackets in such expression as
3(x+4) - 5(2x+3) + 2(5x-6).
Multiplication of expressions such as
(2x-3) (5x+4), (x-4) (x² - 5x - 11) etc.
Division of expressions such as
(2x² + 11x - 15) ÷ (x+3), (6x² + x - 12) ÷ (3x - 4),
(6x³ - x² - 33x - 28) ÷ (3x+4).

FACTORS

Use of the distributive law in the factorising of such expressions as 6xy+3y², ax-by-bx-ay.
Factors of quadratic expressions of the form
x² + bx+c, where b, c are in Z.

EQUATIONS

Formation and interpretation of number sentences leading to the solution of first degree equations in one variable. Quadratic equations of the form
x² + px + q = 0, where x² + px + q is readily factorisable.

STATISTICS

Drawing and interpreting bar-charts, pie-charts, trend graphs.

SCIENTIFIC NOTATION

Non-zero positive rationals expressed in the form
a·10ⁿ, where n ∈ Z and 1 ≤ a < 10.

TABLES

Use of square, square root and reciprocal tables p.20 to p.27.
CIRCLE

Meaning of radius, diameter and chord as line segments.

Length of circle
Length of diameter

3.14 or $\frac{22}{7}$ may be taken as approximations for $\pi$.

Use of formulae provided in the Tables for length of circle and surface area enclosed by a circle.

TRANSLATION

Couples. Equipollent couples. It can be assumed that

(i) translation conserves length
(ii) image of a line under a translation is a parallel line. Construct the image of a set under a translation using compass and set square.

It can be assumed that

(a) when a transversal cuts two parallel lines then
   (i) Corresponding angles are equal in measure
   (ii) Alternate angles are equal in measure.

(b) two triangles are congruent if two sides and the included angle in one are equal in measure to two sides and the included angle in the other.

THEOREM

Vertically opposite angles are equal in measure. (*)

THEOREM

Opposite angles in a parallelogram are equal in measure. (*)

THEOREM

The three angles of a triangle sum to 180°. (*)

THEOREM

The external angle of a triangle is equal in measure to the sum of the two interior opposite angles. (*)

THEOREM

Base angles of an isosceles triangle are equal in measure. (*)

THEOREM

Angle in a semicircle is a right angle. (*)

CONSTRUCTION

Construct the bisector of a given angle.

SECTION THREE

RELATIONS AND FUNCTIONS

Coordinating the plane. Drawing graphs of the function $f$: $x \rightarrow f(x)$, where $f(x)$ or $y$ is of the form $3x + 4$.

EQUATIONS

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

COORDINATE GEOMETRY

Distance formula. Slope. Mid-point formula. Equation of line in the forms $y - y_1 = m(x - x_1)$ and $y = mx + c$. (These formulae will be given on the examination paper).
<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound Interest</td>
<td>Interest added at regular intervals to a maximum of three. (Formula not required).</td>
</tr>
<tr>
<td>Tables</td>
<td>Use of formulae provided in the Tables for surface area and volume of cylinder and sphere.</td>
</tr>
<tr>
<td>Statistics</td>
<td>Expression of discrete array as a frequency table. Mean and mode.</td>
</tr>
<tr>
<td>Quadratic Functions</td>
<td>Graphical illustration and interpretation of quadratic functions of the form $x \rightarrow x^2 - 5x + 6$.</td>
</tr>
<tr>
<td>Factors</td>
<td>Factors of expressions of the form $ax^2 + bx + c$, where &quot;a&quot; is prime. Factorisation of the difference of two squares.</td>
</tr>
<tr>
<td>Equations</td>
<td>Quadratic equations in one variable having rational roots only. Use of formula acceptable but not essential. Simple problems leading to quadratic equations.</td>
</tr>
<tr>
<td>Algebraic Expressions</td>
<td>Addition and subtraction of the form $\frac{1}{x+a} + \frac{1}{x+b}$, $a, b \leq 2$. Equations of the form $\frac{1}{x-1} - \frac{1}{x} = \frac{1}{2}$.</td>
</tr>
<tr>
<td>Trigonometry</td>
<td>Cos, sin and tan of angles. Reading trigonometrical tables. Solving right angled triangle problems of a simple nature in heights and distances involving compass directions. (Theorem of Pythagoras may be assumed).</td>
</tr>
<tr>
<td>It can be assumed that</td>
<td>(a) two triangles are congruent if one side and two angles in one are equal in measure to a corresponding side and two angles in the other.</td>
</tr>
<tr>
<td>Theorem</td>
<td>The opposite sides of a parallelogram are equal in length. (*)</td>
</tr>
<tr>
<td>Theorem</td>
<td>The diagonals of a parallelogram bisect each other (*)&amp;</td>
</tr>
<tr>
<td>Construction</td>
<td>Show how to trisect a given line segment.</td>
</tr>
</tbody>
</table>
THEOREM
A diagonal bisects the area of a parallelogram (*).

THEOREM
The area of a parallelogram abcd is \(|a b| \cdot h\), where h is the distance of c from ab (The area of a triangle is given in the Tables). (*).

AXIAL SYMMETRY
Construct the image of a set under an axial symmetry using compass and set square.

THEOREM
The image of a circle under the axial symmetry in a line through its centre is the same circle. (*)

CENTRAL SYMMETRY
Construct the image of a set under a central symmetry using a compass.

(*) Proofs of theorems will not be examined.
INTERMEDIATE CERTIFICATE

MATHEMATICS

SYLLABUS C

SECTION ONE

SETS

RELATIONS
Couples. Use of arrow diagrams to illustrate relations of the form "is greater than".

NATURAL NUMBERS
The set N. Place value idea. Addition, subtraction, multiplication and division in N so that the answer is in N. Order of precedence. Removal of brackets. Approximate answers. The commutative property. Meaning of \( a^n \) for \( a, n \in \mathbb{N} \) and \( n \neq 0 \). Sets of multiples. Lowest common multiple.

INTEGERS
The set Z. Addition. Positional order in the number line.

RATIONAL NUMBERS
The set \( \mathbb{Q}^+ \). Emphasis on fractions having 2, 3, 4, 7, 8, 16, 5, 10, 100, 1000 as denominators. Equivalent fractions. Addition, subtraction, multiplication and division in \( \mathbb{Q}^+ \). Approximate answers. The above fractions excluding 3, 7, 16, as denominator expressed as decimals.

MEASURE
S.I. units of length, area and mass. Time (applications to 24 hour clock and to transport timetables).

MONEY
Shopping bills.

GEOMETRICAL INSTRUMENTS
Ruler, protractor, compass and set squares. To measure the length of a given line segment, the size of a given angle, the area of a given square or rectangle, the perimeter of a given square or rectangle. To construct line segments of given lengths, squares and rectangles of given measurements.

SECTION TWO

DECIMALS
Place value. Addition, subtraction and multiplication. Rounding off to not more than three decimal places. The practice of approximating before evaluation.

PERCENTAGE
Fraction to percentage (\( \frac{32}{100} \) is 32%). Suitable fractions and decimals expressed as percentages. Equivalence of fractions, decimals and percentages (\( 42 = 0.42 = 42\% \)).
MONEY

Percentage discount. To calculate selling price when given the cost price and the percentage profit or loss. To calculate the percentage profit or loss when given the cost and the selling prices.

STATISTICS

Drawing and interpreting bar-charts, pie-charts and trend graphs.

CONSTRUCTION

Construction of triangles when given the lengths of three sides, the lengths of two sides and the measure of the included angle, the length of a base and the measures of the base angles. Use of protractor to verify that the measures of the three angles of a triangle sum to $180^\circ$. Construction of rt angled triangle, verification of theorem of Pythagoras by finding the areas of the squares on the three sides.

Verification by paper cutting or otherwise that a rectangle is bisected by a diagonal and that the area of a triangle is half the area of an associated rectangle. To construct and measure the height of a triangle when given a base. Area of triangle is half the length of base by the height.

MEASURE

Volume of rectangular solids.

\[ \text{Speed} = \frac{\text{Distance}}{\text{Time}} \]

EVALUATING EXPRESSIONS

For example: find the value of $3x + 7y$ for $x, y \in \mathbb{Q}$.

EQUATIONS

Linear equations in one variable where the solution is a natural number.

E.g. Solve $3x + 4 = 19$.

SECTION THREE

INTEREST

Compound interest for not more than three years.
Calculating income tax.

BILLS

Electricity, telephone, gas, etc. V.A.T. Applications to meter readings and to fixed and variable charges.

STATISTICS

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

EVALUATING EXPRESSIONS

Quadratic expressions of the form $x^2 + px + q$ where $p, q$ and $x \in \mathbb{N}$

For example: find the value of $x^2 + 5x + 7$ when $x = 4$.

TABLES

Use of square root and square tables.

SCALES

Calculating distance from a map. Drawing to scale.

GRAPHS

Plotting points having integral coordinates. Joining points to form a line.
Draw the graph of $y = 3x + 5$ from $x = 1$ to $x = 6$, $x \in Q^+$

**CONSTRUCTION**

Idea of parallel lines and of perpendicular lines. Use of set squares to draw a line through a point parallel to a given line. To bisect a given angle. To divide a line segment into two or more equal parts.

**CIRCLE**

Meaning of radius, diameter and chord as line segments.

- Length of circle $\Rightarrow \pi$.
- Length of diameter $\frac{22}{7}$.

3.14 or $\frac{22}{7}$ may be taken as approximates for $\pi$.

To verify by measurement that the angle in a semi-circle is a right-angle and that the opposite angles in a four-sided figure inscribed in a circle sum to $180^\circ$.

To construct a tangent at a given point of a circle. To circumscribe a square about a circle and to inscribe a square in a circle. The relation between the areas of these two squares for a given circle.

**AREA AND VOLUME**

Volume of a cylinder.

**SYMMETRY**

Use of instruments to construct the image under (i) axial symmetry (ii) translation.
APPENDIX B

LETTER FROM CONCERNED PARENT
Dear Editor,

As a concerned and worried parent I would like to ask Readers for their opinion on problems which I have experienced with regard to my son who is in Secondary school and who has the misfortune of having a very bad Maths teacher.

My query is, how does a parent deal with this problem? My son's teacher is abusive, discouraging, vindictive and is definitely undermining my son's ability to do Maths and his love for that subject (who up to this year has always had excellent grades).

To whom does one turn? It is useless and even damaging to approach the teacher concerned as any suggestion that there's a problem might result in vindictive action on his part against my son, thereby making the child's life a complete misery.

Well, there's always the Principal — but he has no redress against the teacher and can only gently hint that there's a problem — the teacher in the classroom is untouchable.

So, I turn to the Dept. of Education. There, one is just dealing with Bureaucracy and gets nowhere. After all, the teacher is employed by the Board of Management, paid by the Dept. and monitored by no one.

Try your local T.D. and he just puts your letter in the bin.

So the original problem still remains, the teacher continues to pursue his ineffective teaching methods and my son's grades and confidence continue to slide down-hill.

Any suggestions?

E. Maher,
Co. Clare.
APPENDIX C

ATTITUDES OF PUPILS TO JUNIOR CYCLE MATHEMATICS: SEMI-STRUCTURED INTERVIEW QUESTIONNAIRE
ATTITUDE TO MATHEMATICS AT JUNIOR CYCLE LEVEL

1. Attitude of the pupil to the school as a whole.

In relation to the school as a whole, how do you feel about the following?

(a) Are you reasonably happy with the school?
   If not, what areas would you like to see an improvement in?

(b) Would you agree there is a good balance between the academic and the P.E./Practical subjects?

(c) Do you feel there is a good atmosphere in the school?

(d) In relation to your school subjects, are you ever asked for opinions, comments or encouraged to express your views?

2. Pupil confidence

(a) Do you feel confident in being able to solve maths problems?

(b) Do you like solving difficult problems?

(c) Are there occasions when you just can't do mathematics?

(d) Do you give up easily when you get stuck in a Maths problem?

(e) Would you say your confidence at Mathematics has remained at the same level, disimproved or improved over the three years in the school?

(f) Do you ever dread Mathematics?
3. Satisfaction (Success)

(a) Have you experienced satisfaction from solving mathematics problems?, or a sense of joy from simply achieving the answer in the end?

(b) Do you prefer to do easy problems in mathematics?

(c) 'In Maths there is usually a rule to follow in solving problems'. How do you feel about this? For example, if you can't find a rule, do you give up?

4. Interest

(a) Are you easily distracted during Maths lessons?

(b) Do you find Maths or parts of it interesting?, or is Maths boring?

(c) Do you think Maths is very useful for everyday tasks?

(d) Do you think enough time is spent on mentioning the importance of Maths in our everyday lives?

(e) Do you ever see anything in common between various Maths topics? For example: Sets and Functions? or Algebra and Geometry?

5. Relation to other subjects

(a) Is Mathematics the most useful of all school subjects?

(b) Do you see Maths and Science being closely related?

(c) 'Mathematics is necessary for most good jobs nowadays'. How do you feel about this statement?
6. **Parental attitudes**

(a) Are you ever asked by your parents how you are progressing in Mathematics?

(b) Do they believe Mathematics to be a very important subject?
   - If yes, why? - industry?
   - career use?
   - University importance?

(c) Would they be more concerned about you getting poor results in Mathematics say in relation to Geography?

7. **Home environment/Study habits**

(a) Do you have suitable facilities at home for doing Maths and other homework?

(b) Do you find when doing Mathematics homework that the problems generally are worked out without much mental effort?, or do you usually go through a series of stages before you arrive at your answer?

8. **Miscellaneous: Method of instruction, relevéance of text-books, exam pressures and pupil passivity/activity.**

(a) Does your teacher like to help you tease out the answer in Maths class?, or give you the answer straight?

(b) Would working in groups on Maths problems be a good idea in your opinion?

(b) How relevant have you found the text-books over the three years?

(c) Is the exam the main reason why you would work hard in Maths?

(d) Do you feel the teacher is concerned about getting work covered in time for the exams?

(e) Are mathematics classes generally active with pupils participating or does the teacher do most of the work at the board?
APPENDIX D

ATTITUDES OF PUPILS TO JUNIOR CYCLE MATHEMATICS:

PILOT QUESTIONNAIRE
Dear colleague,

I am currently engaged in research in mathematics education. My area of research is **attitudes of Junior Cycle pupils to mathematics in Irish post-primary schools**. I intend to carry out semi-structured interviews with junior cycle pupils to gain insight into and illuminate the aforementioned issue. To help in the initial pilot phase I would be most grateful if you could take time to rank-order the following twelve subscales in order of importance (1 = the most important etc.).

Thank you in anticipation of your cooperation.

In grateful appreciation,

Joseph English

Joseph English.

(1) Attitude of pupils to school as a whole
(11) Pupil participation in the learning process
(111) Pupil confidence in solving maths problems
(IV) Maths anxiety and sex bias in text-books
(V) Satisfaction and success from maths
(VI) Relation to other subjects
(VII) Maths as an interesting subject
(VII) Exam pressures
(IX) Method of Instruction
(X) Pupils' perceptions of teachers
(XI) Parental attitudes
(XII) Home environment/study habits

Finally, could you please tick as appropriate:

I am currently teaching mathematics to Intermediate level
I am currently teaching mathematics to Leaving Cert. level
APPENDIX E

ATTITUDES OF PUPILS TO SENIOR CYCLE MATHEMATICS: PUPIL QUESTIONNAIRE
PUPIL QUESTIONNAIRE

St. Eunan's College,
March 1st, 1986.

Note: Feel free to skip any of the following questions if you wish. All information will be treated in the strictest confidence.

Q1. Name: ........................................
   Occupation of Parent: ........................................

Q2. What would you like to do on leaving school?
   Choice (1): ........................................
   Choice (2): ........................................

Q3. Do you believe you need a 'Pass' in your mathematics in the Leaving Certificate? Please tick.
   YES
   NO

Q4. What was your attitude to mathematics in Primary school?
   ..............................................................
   ..............................................................
   ..............................................................
   ..............................................................

Q5. What is your attitude to mathematics now after four years in St. Eunan's?
   ..............................................................
   ..............................................................
   ..............................................................
   ..............................................................

Q6. Do you feel that the mathematics done in class is preparing you well for the world of work?
   ..............................................................
   ..............................................................
   ..............................................................
   ..............................................................

Q7. Which parts of mathematics do you think you will find useful when you leave school?
   ..............................................................
   ..............................................................
   ..............................................................
   ..............................................................
PUPIL QUESTIONNAIRE (cont'd)

Q8. Are there any parts of mathematics which you particularly feel will not be of any use when you leave school?

.................................................................................................................................
.................................................................................................................................

Q9. Please attempt all of the following six 'Sums'.

(1) \( \frac{1}{2} + \frac{1}{3} = \ldots \)

(2) (a) \( \frac{1}{5} + \frac{3}{8} = \ldots \)
    (b) \( \frac{3}{5} + \frac{1}{8} = \ldots \)

(3) \[ 30.0 - 22.3 = \ldots \]

(4) \[ 56 - 4\frac{1}{2} = \ldots \]

(5) (a) \( 240/2 = \ldots \)
    (b) \( 240/\frac{1}{2} = \ldots \)

(6) Write in decimal form \( \frac{1}{9} \)
    e.g. \( \frac{1}{2} = .5 \)
    \( \frac{3}{4} = .75 \)
    \( \frac{1}{9} = \ldots \)

Thank you for your help

............................................................
APPENDIX F

ATTITUDES OF PUPILS TO SENIOR CYCLE MATHEMATICS: PARENT QUESTIONNAIRE
Dear Parent,

I am researching into the attitudes of pupils to mathematics in post-primary schools. To help gain an understanding into the part played by parents in the formation of such attitudes, I would be most grateful if you could complete the following questionnaire. All information will be treated in the strictest confidence. Thank you.

Yours appreciatively,
Joseph English (Mathematics Teacher)

Q1. Do you think Mathematics is an important subject? Why?

Q2. Do you believe your son requires a 'Pass' in mathematics to get a job? If your response is 'No' please state why.

Q3. Do you help or talk to your son about mathematics at home? Please tick.

rarely often never

Q4. Are there any changes you would like to see introduced to the current mathematics course?, e.g. Work Experience, visits to industry.

Q5. "Parents should be consulted on the new changes taking place in mathematics at present and on general education issues." Please explain briefly if you agree or disagree with the above statement.

Q6. Please feel free to add any other comment relating to your son's attitude to mathematics that you believe to be relevant.
APPENDIX G

SUMMARY OF ACTION-RESEARCH PRESENTATION TO STAFF, WEDNESDAY 27th JANUARY 1988 4 - 5 pm BY THE AUTHOR
1. **Origin and Background of Action-Research [A/R]**

   - Kurt Lewin (1946) Integrated housing
     Gang Socialisation
     Youth Leaders

   - Corey (1953) - teachers

   - Elliott (1978) and Adelman - Ford Teaching Project: as a means
     a means of helping teachers develop enquiry learning in their
     classrooms

   - Used in Australia also for school-based curriculum development

2. **What is Action-Research?**

   Simply it involves you as a teacher studying your own teaching,
   identifying an interesting aspect, collecting evidence about it and
   then acting on what you find. It is a spiral process.

   **THE MODEL**

   1. Develop a plan of action to improve what is already happening
      in the classroom.
   2. Act to implement the plan.
   3. Observe the effects of action in the classroom.
   4. Reflect on these effects to plan for the future

3. **Why do it?**

   Nobody is perfect. Action-Research may help you improve your
   teaching thus increasing your effectiveness and the quality of your
   pupils' education.
4. How do I study my own teaching?

- Diary of events of part or whole of a lesson
- Tape-recording and listening to it
- Get a colleague in to observe you
- Photographs
- Video-tape
- Check-Lists
- Questionnaires
- Triangulation (see diagram below)

![Diagram of MY VIEWS, PUPILS' VIEWS, and OBSERVER's VIEWS]

5. What areas of my teaching could I look at?

**APPLICATION**

- Teacher/Pupil talk ratio
- Questioning techniques
- Introduction or close of lessons
- Discipline (e.g. distraction stimuli)
- A/V or technology aids.
- Content of the curriculum
- Use of discussion
- Concept development
- Project work etc etc.

6. How much time is needed?

The simple techniques require very little time – 5 or 10 minutes taping or observing in detail the actions of one pupil.

Some techniques require much more.
7. What are the disadvantages?

It can be painful to discover that long-established beliefs or habits are of dubious benefit. Also, very sensitive people can feel threatened. Any people I know who do A/R cope adequately. Of course if you are an exceptionally able teacher and your research confirms it, you may feel you have wasted your time - I have yet to meet that guy. Self confidence may also be required.

8. And the Advantages?

- More status as a professional
- Gap between theory and practice closes - teachers generate their own theory from classroom practice
- More effective teachers
- More professional growth and development and job satisfaction (skills improved)
- Accountability fears can be allayed
- More empowered teachers who are in control of their professional futures
- Can encourage collaboration with peers

9. Conclusion

Action-Research is an effective research strategy to help avoid the Laing (1970) malady; "He does not think there is anything the matter with him because one of the things that is the matter with him is that he does not think there is anything the matter with him at all."

REFERENCES

APPENDIX H

SELF-EVALUATION INSTRUMENT: REACTION CHECKLIST
Q1. Do you value self-appraisal as a worthwhile process? YES [ ] NO [ ]

Q2. Do you consider the self-evaluation instrument to be beneficial? YES [ ] NO [ ]

Q3. In relation to the instrument, please tick the appropriate box(es):
   The form is too long
   The form is about right
   The section headings on their own would be sufficient

Q4. What are the main advantages?

Q5. What are the major disadvantages?

Q6. Any other comment (e.g. further deficiencies or suggestions for improvement)?
APPENDIX I

REACTION OF ULSTER TEACHERS' UNION TO AD-HOC APPRAISAL SCHEMES IN THE NORTH-EASTERN AREA OF NORTHERN IRELAND
Dear School Representative,

APPRaisal OF TEACHERS

At the September meeting of the Central Executive Committee of the Union, members were concerned to learn that ad hoc schemes for the appraisal of teachers were being introduced in some Primary Schools in the North-Eastern Board area.

It would appear that these schemes have been initiated by an Officer of the Centre for Education Management although the Union has received an assurance from the Chairman of the Management Committee, Prof. J F Fulton, that the Centre has dissociated itself from them.

Accordingly the Central Executive Committee strongly advises members not to engage in any ad hoc schemes of appraisal at present being operated in schools.

The Union recognises that the appraisal of teachers will become obligatory under Clause 40 of the Education Act and that agreement has already been reached thereon in the Coventry Heads of Agreement based on the Report of the ACAS Working Group on Appraisal and Training. However the recommendations of this Report in England and Wales will be directed and monitored by a National Steering Group comprised of representatives of recognised unions and officers of the Department of Education and Science and Local Education Authorities. The Union would expect similar representative rights when, and if, pilot projects on appraisal are introduced in Northern Ireland as part of salary restructuring.

I would be grateful if you would convey this advice to UTV members forthwith.

Yours sincerely,

[Signature]

[Name]
General Secretary.
APPENDIX J

EVALUATION INSTRUMENT: ENCLOSURES

(1) COVER LETTER
(11) SYNOPSIS OF AUTHOR'S WORK *
(111) QUESTIONNAIRE

* The Figure 2 mentioned in this section is not included as it corresponds to Figure 4 in the main text of the thesis.
Dear colleague,

I am a secondary mathematics teacher engaged in research for a Ph.D. degree in Mathematics Education. My Director of research is Professor A.C. Bajpai, OBE, Loughborough University of Technology and my Local Supervisor is Dr. John O'Donoghue, Thomond College of Education, Limerick.

The main focus of my research has been an analysis of Appraisal as a major issue for the teaching profession in general, with a special emphasis on Secondary Mathematics Teachers.

As an outcome of my research over the past three years, I have devised a model for a national system of appraisal together with a self-appraisal instrument, designed for use by secondary mathematics teachers. The validation of the model and instrument is an essential part of the innovative work.

As a representative of the educational system, I hope you find time to complete the enclosed questionnaire. To inform this activity, I have supplied a synopsis of my work to-date. The model and instrument are preceded by a positive rationale for the introduction of appraisal.

I know there are many demands on your valuable time. I would be entirely grateful if you could arrange to have the questionnaire completed. Your response is most important at this stage of my research. As I realise that such chores as completing questionnaires can easily get overlooked in crowded working schedules, please do not be annoyed if you receive a reminder in due course. Thanking you in anticipation of your co-operation.

In grateful appreciation,

Joseph English

Enclosures:
1. Synopsis of present work
2. Questionnaire
3. Prepaid envelope
A. A POSITIVE RATIONALE FOR THE INTRODUCTION OF APPRAISAL

1. It is possible to distinguish between two types of appraisal: informal and formal. Informal or 'crude' appraisal is carried on all the time by colleagues, principals, pupils, parents and by society in general. Such appraisal is unsatisfactory because it is unstructured, haphazard, idiosyncratic in nature and buttressed by subjective judgements and hearsay evidence.

INFORMAL APPRAISAL IS WIDESPREAD BUT UNSATISFACTORY

2. Appraisal has an important role in helping mathematics teachers adapt to a rapidly changing world. Appraisal has the potential to enhance teacher professional development. Involvement in appraisal can lead to a reduction in stress and anxiety for mathematics teachers by providing a temporary palliative for those whose careers appear to be blocked in terms of increased job-satisfaction, variety in work and improved classroom performance.

APPRAISAL HAS SEVERAL POSITIVE ADVANTAGES

3. Appraisal ought to be linked to in-school planning and review. More open and effective school management can accrue as appraisal can help mathematics teachers develop skills in curriculum development, staff development and peer activities. These skills can produce a 'knock-on' effect and enhance the morale, enthusiasm and coherence of the school as a unit.

APPRAISAL SHOULD NOT BE ISOLATED FROM IN-SCHOOL PLANNING AND REVIEW PROCEDURES

4. The age of accountability has long been ushered in. Mathematics teachers will soon have to accept increasing professional responsibility for continual self-improvement. In this context, self-appraisal by mathematics teachers has the potential to enhance professional effectiveness in the classroom, raise morale and give more personal control to mathematics teachers over their own teaching.

SELF-APPRaisal HAS AN IMPORTANT ROLE IN ANY APPRAISAL SYSTEM, FORMAL OR OTHERWISE

5. Appraisal can help meet the legitimate demand to be open and accountable, while at the same time offering support to mathematics teachers as a valuable tool in helping them recognise and improve the effectiveness of their practice.

ACCOUNTABILITY, APPRAISAL AND EFFECTIVE MATHEMATICS TEACHING ARE INTERRELATED
6. A formal system of appraisal involving classroom observation is necessary. However, in practice, appraisal should not focus solely on classroom performance. It should also include an appraisal of peer/collegial skills, leadership ability together with a consideration of the teacher’s general contribution to the school and community.

FORMAL CLASSROOM OBSERVATION IS NECESSARY BUT NOT SUFFICIENT

7. Unless there is progress in developing an awareness of what appraisal could and should mean and in developing a credible system of appraisal, there is a risk that a unique opportunity to improve the education of our young people will be lost, that public funds will be wasted and that the state of education will be no better than before. A national system of appraisal can have an uplifting effect upon the climate and quality of secondary education. Mathematics teachers‘ worth will be better recognised and their professionalism extended.

A NATIONAL SYSTEM OF FORMAL APPRAISAL IS NECESSARY

B. A PROPOSED MODEL FOR A NATIONAL SYSTEM OF APPRAISAL

---

Figure 1: A three-tier model for a national system of appraisal
FEATURES OF THE MODEL:

1. It is a national model designed to meet the need for genuine external accountability.

2. The model is designed to include:
   (1) self-appraisal (which allows for pupil feedback)
   (II) peer appraisal
   (III) formal appraisal of teachers by principals or another senior teacher
   (IV) formal appraisal of principals by specially trained appraisal officers
   (V) an appeals and monitoring procedure

3. The following assumptions underpin the model:
   (1) Appraisal is a continuous process not an event, requiring skills, empathy, sensitivity and trust to ensure credibility.
   (II) The national system will evolve over a period of time.
   (III) The model is the ideal one based on the assumption that the concept of regionalisation of education structures is both desirable and inevitable as advocated in Hussey's (1985) Green Paper Partners in Education. The present VEC administrative districts could provide boundary regions for the LEC's as could existing Health Boards or Regional Development Areas.
   (IV) The primary purpose of appraisal is developmental involving teacher commitment to continual improvement in performance.
   (V) Extensive consultation on the design and implementation of the scheme is necessary for successful appraisal.
   (VI) The bottom-up aspect of the model effectively makes mathematics teacher shareholders in the initiative, thus enhancing the prospects of successful implementation and sustainment.
   (VII) The criteria for effective mathematics teaching are negotiated and agreed jointly between the appraiser and mathematics teacher before classroom observation.
   (VIII) The skills of appraisal will be developed through a substantial training programme for all those involved.
   (IX) Adequate resources, including time, finance, materials and in-service education, will be made available to enact the consequences of appraisal.

C. A SELF-EVALUATIVE INSTRUMENT FOR SECONDARY MATHEMATICS TEACHERS

Formal classroom observation should be preceded and informed by a self-appraisal. The self-evaluative instrument in Figure 2 is advanced as an aid in this self-monitoring process. It is based on research into effective mathematics teaching. The checklist is not intended to be prescriptive, exclusive or exhaustive. For improvements to occur, it is the reflection, deliberation and subsequent action taken by the mathematics teacher that really counts.

The list may well be too long to deal with fully at any one occasion and one suggestion might be to focus on one or more aspects of the instrument at a time. It is also possible and preferable for mathematics teachers to modify or indeed devise their own checklist as they gain in confidence and familiarity.
TEACHER APPRAISAL QUESTIONNAIRE

Please read the following questions carefully and answer as appropriate. Some questions may require you to tick more than one box.

1. Please indicate which category you belong to:
   - Principal
   - Mathematics teacher
   - C.E.O.
   - Ministry of Education Inspector
   - Other

2. Do you value the notion of appraisal in general in education?
   - YES
   - NO

3. Do you operate appraisal in your context?
   - YES Go to Q.4
   - NO Go to Q.5

4. What type of appraisal do you operate?
   - Self-appraisal
   - Informal appraisal
   - Formal appraisal
   - Institutional appraisal

5. What, in your opinion, should be the main purpose(s) of appraisal considering the following possibilities:
   [Please tick appropriate box(es)]
   - To assess training and development needs
   - To help improve current performance
   - To review past performance
   - To assess future potential/promotability
   - To assist career-planning decisions
   - To set and agree performance objectives
   - To provide a basis for reward (salary) decisions
6. What is your view of the desirability of setting up a national system of appraisal?
   - In Favour
   - Not in Favour
   - Undecided

7. Is the National Model, as represented in Fig. 1 viable in its present form?
   - YES Go to Q. 9
   - NO Go to Q. 8

8. Please identify what you consider to be the main deficiencies:
   

9. Do you value self-appraisal as a worthwhile process?
   - YES
   - NO

10. Do you consider the self-evaluative instrument as contained in Fig. 2 to be beneficial?
    - YES
    - NO

11. In relation to the instrument, please tick the appropriate box(es):
    - The form is too long
    - The form is about right
    - The section headings on their own would be sufficient
    - The form can help inform formal appraisal
    - A standard checklist within each school would be better
12. Which aspects of a teacher's work should be considered for the purpose of performance appraisal?

- Contribution to academic activities in the school
- Contribution to extracurricular activities
- Performance of other professional duties

13. Which of the following should be involved in deciding the criteria which should be used for a system of teacher appraisal?

- Mathematics teacher being appraised
- Principal
- Senior staff
- Others (please indicate)

14. In performance appraisal, do you think classroom observation should form part of the process?

- YES
- NO

15. In your opinion, do present Irish education structures facilitate the introduction and implementation of successful appraisal?

- YES
- NO

16. Any Other Comment?

-------------------------------------------------------------

THANK YOU FOR YOUR HELP IN ANSWERING THIS QUESTIONNAIRE.

******************************************************************************
APPENDIX K

A PUPIL WORKSHEET ON "COMPUTERS AND STATISTICS"
1. What is "Viewplot" used for?
2. What is a label and give an example?
3. What is a format file?
4. How does one add and remove data?
5. How does one jump to a particular entry?
6. How does one load and save data from the disk drive?
7. How is "Autoentry" turned on and what is it used for?
8. What is the procedure to clear the screen and start with a new data set?

Questions 9 - 13 are based on the diagram below?

9. What is the total number of data entries?
10. Is "Auto entry" on or off?
11. Enter the data set given below and use the package to draw:

   (1) a histogram
   (11) a line graph
   (111) pie-chart

12. Explore what happens if you switch the data between the X and Y axes?
13. Investigate the possibility of getting an infinite number of sectors on the pie-chart by extending the data set. You may work in groups of two on this task.

14. Write down four applications of the "Viewplot" package?
15. What I liked most about the last two lessons was ____________________________
APPENDIX L

A PUPIL WORKSHEET ON "MATHEMATICS AND THE CALCULATOR"
It is very easy to key in a wrong number into a calculator without realising it. To avoid mistakes you should make a rough guess at the answer yourself and if you are in any doubt go through the calculation a second time. To make rough guesses we round off figures to the nearest ten, hundred, or thousand. For example suppose we multiply 4015 x 105 and the calculator gives 4,235,825. This figure seems too big because 4000 x 100 = 400,000. So go through the calculation again. Can you work out what the mistake was originally? 4015 x 105 = 421,575.

Do the following calculations now, but don’t forget to make rough guesses at the answers.

(i) 5408 x 1091
(ii) 6356 x 98
(iii) 5621 + 3080
(iv) 6128 + 52

Square Roots

The square root of a number is that number which when multiplied by itself gives the original number.

Example: 5 is the square root of 25 because $5^2 = 25$.

To find square roots we use the √ key.

Example: $\sqrt{36} = 6$

Find the following square roots:

(i) $\sqrt{16}$
(ii) $\sqrt{54}$
(iii) $\sqrt{49}$
(iv) $\sqrt{81}$
(v) $\sqrt{60}$

Squares

To square a number, which means to multiply it by itself, enter it and press the x² key. If your calculator does not have an x² key, enter the number press × and = and the number will automatically be squared.

Example (i) $7 \times 7 = 49$
(ii) $7 \times 7 = 49$

Are the following true?

(i) $32^2 + 63^2 + 79^2 = 23^2 + 36^2 + 97^2$
(ii) $33^2 + 69^2 + 72^2 = 33^2 + 96^2 + 27^2$

Calculations often give answers which are far more accurate than we need. For instance, if you were to share out 18 cakes amongst 7 children, the calculator would tell you to give each child 2.5714285 cakes. This figure is too accurate for us so we round off to, say, one place of decimals. To do this we take the second figure after the decimal point. If it is less than 5 we ignore it. So in this instance each child gets 2.6 cakes or slightly over 2 3/4 cakes.

Do the following divisions and round off to one place of decimals.

(i) 11 ÷ 6
(ii) 16 ÷ 11
(iii) 35 ÷ 12
(iv) 95 ÷ 27
(v) 101 ÷ 14

Reciprocals

The reciprocal of a number is that number divided into 1. There are two methods for finding reciprocals.

Example find the reciprocal of 27.3

Method 1: $\frac{1}{27.3} = 0.036630036$

Method 2: $\frac{1}{27} \times 1 = 0.036630036$

Method 1 always works but Method 2 may only be used when a calculator has a $\div$ key.

Now do all the questions from the log tables chapter again by calculator; you can see how accurate or otherwise the tables are.

Reappearing squares puzzle

$5^2 = 25 \quad 6^2 = 36 \quad 25^2 = 625$

Above there are three numbers which when squared reappear as the last figure or figures in the answer. There are only three other numbers between 25 and 1000 which do this. Can you work out which they are?
APPENDIX M

A SAMPLE COLLECTION OF MATHEMATICAL GAMES AND PUZZLES
Millions!

Write in figures the following number:
eleven million, eleven hundred thousand,
eleven hundred and eleven.

Work it out!

Five girls were given a job to do.

A could do the job in 1 minute.
B could do the job in 2 minutes.
C could do the job in 3 minutes.
D could do the job in 4 minutes.
E could do the job in 5 minutes.

If the five girls work together how long
would it take them?

A Good Age

Peter is now twice as old as John was when
Peter was as old as John is now. John is
18. How old is Peter?

Make your Century

Can you use all the digits from 0 to 9 to
make two numbers which when added
together make 100. (Hint: Use whole
numbers and fractions.)

Monkey Business

A monkey is at the bottom of a well. A 10
metre rope reaches from the top to the bot-
tom. Every minute he climbs up 3 m,
but slips back 2 m. How long does it take
him to reach the top?

No Crossing

Can you join A to A, B to B, C to C and
D to D without crossing lines?

Balancing Act

Given eight snooker balls, one of which is
lighter than the rest, how would you find
the light one by only two weighings on a
balance scale?

More than you think

How many triangles in this figure?

An Ancient Puzzle

A man lived \( \frac{1}{4} \) of his life as a boy; \( \frac{1}{2} \) as
a youth; \( \frac{1}{3} \) as a man and 13 years after
that. How old was he?

Impossible!

Let \( a = b = 1 \)

\[ a^2 = a \times b \]

\[ a^2 - ab = a^2 - b^2 \]

\[ a(a-b) = (a+b)(a-b) \]

\[ a = (a + b) \]

\[ 1 = 1 + 1 \]

\[ 1 = 2 \]

Where is the flaw?
APPENDIX N

PARENT INFORMATION SHEET ON "THE NEW JUNIOR CYCLE MATHEMATICS COURSES"
INFORMATION SHEET ON:

THE NEW JUNIOR CYCLE MATHEMATICS COURSES

Dear Parent,

As and from September 1987, all first-year pupils will take the new Junior cycle mathematics courses. The last revision of these syllabi took place in 1973.

What's new: The old syllabi offered mathematics at two levels - Pass and Honours. In recent years, much dissatisfaction was expressed at the unsuitability of the Pass course for the majority of pupils. In particular, very high failure rates have been recorded by those pupils at the lower end of the ability spectrum. In an attempt to meet the demands and needs of all pupils, the amended syllabi are being offered at three levels:

- Syllabus A - intended for the more able pupils
- Syllabus B - intended for those pupils of average ability
- Syllabus C - intended for pupils who find mathematics difficult.

The three new syllabi are based on a 'content-orientated' approach; for example, while geometry is included on all three syllabi, the formal learning of theorem proofs is not required from those taking either syllabus B or C.

Examinations: The Intermediate Certificate Examination will continue to be set on the present syllabi up to and including 1989 but the Examination in 1990 and until further notice will be based on the new syllabi.

Leaving Certificate Progression: Currently, amended syllabi at Leaving Certificate level are being prepared - also at three levels to facilitate a natural progression from the newly amended Junior cycle syllabi.

I hope you find the above information useful. The school will be only too willing to supply additional information.
APPENDIX O

AUTHOR'S SUBMISSION TO THE CURRICULUM AND EXAMINATIONS BOARD'S DOCUMENT: "MATHEMATICS EDUCATION: PRIMARY AND JUNIOR CYCLE POST-PRIMARY"
Dear C.E.O.,

In your recent discussion paper "Mathematics Education: Primary and Junior Cycle Post-Primary", you invited a response on the document as part of your consultative process. As a concerned secondary mathematics teacher I would like to avail of this opportunity and communicate to you my views and comments.

A major criticism lies in the failure of the document to provide a worthwhile justification for attaching great importance to the teaching and learning of mathematics even though on page 5 it is stated that the central role of mathematics in the education of young people has too often been taken for granted. Although the discussion paper does address such issues as the need to provide a rich mathematical experience for all students, the need to foster positive attitudes towards mathematics etc., it is questionable whether these constitute the central and key issues when a number of fundamental questions were omitted. These include such questions as:

What is it that we want students to learn?
How can we structure the mathematics curriculum so that the underlying framework not only facilitates learning, but also illuminates our mathematical objectives?
How is the learning of mathematics to be structured and how is the acquisition of such structures to be facilitated?
How does mathematics relate to general educational goals?
What is the place of mathematics in a technological society?
Who will teach mathematics and how will they teach it?

A consideration of such questions would serve to facilitate the justification of the place and aims of mathematics in schools.

On the issue of aims and objectives, the attempt in the paper to specify these for mathematical education is lacking, as they are too general to be of any benefit in the development of worthwhile mathematics programmes.

As a secondary mathematics teacher I am disappointed to find how little attention is given to the problem of teaching mathematics. The paper provides no strategies for the secondary mathematics teacher by which he might improve his current unsatisfactory position which is characterized by isolation, traditional routines, no time
for reflection, acquiescence and poor professional standing. I suggest such professional processes as action-research and self-appraisal be given serious consideration. As a practitioner operating in a depowering system the paper was a major disappointment.

Although the paper indicates a willingness to confront some of the problems in secondary mathematics education there are additional deficiencies. Notable omissions include:

- no consideration of the potential role of mathematical advisers in the improvement of secondary mathematics teaching
- no reference to the establishment of a research centre for mathematical education
- no searching analysis of the role of the electronic calculator and microcomputer in the teaching and learning of mathematics
- no elaboration of how suggested changes are going to be implemented at classroom level
- no attempt to identify the elements involved in bringing about change in mathematics education or the role of the mathematics teacher in the change process
- no mention is made of the cultural significance of mathematics in our national context
- no strategies are given for breaking the stranglehold of the universities on the teaching of secondary mathematics
- no suggestions for reducing the distorting affect of examinations on the teaching and learning of secondary mathematics.

In conclusion, my hope is that these views and comments will receive your considered attention in the quest for an improved quality of mathematics teaching and learning at secondary level.

Yours sincerely,

Joseph English

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