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"AN INVESTIGATION INTO THE PRE-
SERVICE TRAINING OF SECONDARY
SCHOOL MATHEMATICS TEACHERS AT
COLLEGES OF EDUCATION
ADMINISTERED BY THE
HOUSE OF REPRESENTATIVES."

by

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I dedicate this study to my late father who has always been keenly interested and proud of my work.

ABSTRACT

This study involves an investigation into the nature and effectiveness of the pre-service training, where provided, of secondary school Mathematics teachers at the 11 colleges of education administered by the House of Representatives in the Republic of South Africa.

The purpose of this study is to determine whether the HDE (Secondary) course offered at some of the aforementioned colleges of education is justified, in spite of the fact that it contravenes the requirements of the Education Act, No.73 of 1969.

Three different questionnaires were designed and during 1986 were sent to heads of Mathematics departments at the aforementioned colleges of education, to Mathematics teacher educators at these colleges and to beginning secondary school Mathematics teachers, teaching at schools administered by the House of Representatives in the Eastern Cape and Natal.

The findings of this study show that the secondary course for Mathematics teachers is only offered at 5 of the 11 colleges of education and only a small percentage of

students take this course. During 1986 most of the Mathematics teacher educators at the colleges of education were not suitably qualified. The study also shows that the Mathematics curriculum for the training of secondary school teachers is inadequate and a revision thereof is thus recommended. An obvious conclusion drawn from the findings is that the training of secondary school Mathematics teachers at these colleges of education is still in an early stage of development.

One of the main recommendations of this study is that the training of secondary school Mathematics teachers at colleges of education administered by the House of Representatives should be terminated, in view of its ineffectiveness and in accordance with Education Act, No. 73 of 1969. On the other hand, in case this is not possible, suggestions are also made for the improvement of the pre-service training of secondary school Mathematics teachers at these colleges of education.

LIST OF ABBREVIATIONS

BACOMET	BASIC COMPONENTS OF MATHEMATICS IN THE EDUCATION OF TEACHERS
DE	DIPLOMA IN EDUCATION
HDE	HIGHER DIPLOMA IN EDUCATION
HSRC	HUMAN SCIENCES RESEARCH COUNCIL
ICME	INTERNATIONAL CONGRESS ON MATHEMATICAL EDUCATION
JPTC	JUNIOR PRIMARY TEACHERS' CERTIFICATE
MASA	MATHEMATICAL ASSOCIATION OF SOUTH AFRICA
PTC	PRIMARY TEACHERS' CERTIFICATE
PTD	PRIMARY TEACHERS' DIPLOMA
RSA	REPUBLIC OF SOUTH AFRICA
STD	SECONDARY TEACHERS' DIPLOMA
UED	UNIVERSITY EDUCATION DIPLOMA
USA	UNITED STATES OF AMERICA

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INTRODUCTION AND OVERVIEW

For the past fifteen years I have been directly involved with both the pre-service and in-service training of Mathematics teachers, both as a lecturer at a college of education and as a senior subject adviser (Mathematics) for the Department of Education and Culture: House of Representatives.

After completion of my initial training as a secondary school teacher at the University of the Western Cape, I accepted a post as lecturer at a college of education. In spite of having had no previous teaching experience, I was immediately confronted with the task of training prospective primary and secondary school Mathematics teachers. Having had no tertiary training experience I initially encountered much difficulty with the handling of the section on Subject Didactics. The available syllabi were not specific enough and no departmental guidelines for the training of teachers of Mathematics were available.

The general pattern of instruction followed by most of the other lecturers for the teaching of Subject Didactics promoted rote learning by the students of certain topics from a departmental guideline designed for the junior primary phase. Available lecture notes were compiled from material

which had been used by the lecturers during their own initial training periods.

Communication with lecturers from the other training institutions did not bear much fruit as the same pattern of approach emerged. The general trend was that Subject Didactics was being neglected and that most of the lecturing time was utilized for teaching the content section of the syllabi.

Faced with this problem I was compelled during the first few years to obtain and compile some suitable study material for the teaching of Subject Didactics. Reference material on the teaching of Mathematics in the college library was largely limited to copies of secondary school textbooks and reference material from a local university library had to be utilized.

In my present capacity as senior subject adviser for secondary teachers of Mathematics, I have direct contact with approximately 170 Mathematics teachers from 49 secondary schools. During informal discussions and inspection visits it has become evident that the sections on Subject Didactics are still generally being neglected by most lecturers and that rote learning of lecture notes seems still to be the general approach.

As a direct consequence of my personal experiences, I propose to investigate the nature and effectiveness of the pre-service training of secondary school Mathematics teachers at colleges of education under the control of the House of Representatives.

The general aims of this investigation can be summarized as follows:

- (a) To determine the nature and effectiveness of the pre-service training of secondary school Mathematics teachers provided by colleges of education administered by the House of Representatives.
- (b) To determine the attitude of the lecturers at colleges of education towards the pre-service training of secondary school Mathematics teachers.
- (c) To determine the attitude of beginning secondary school Mathematics teachers towards their pre-service training.
- (d) To evaluate the current Mathematics syllabi offered for the pre-service training of secondary school Mathematics teachers at colleges of education and to present possible proposals for a revision.

The field of study is dealt with in Chapter 1. It includes discussions of the training of secondary school teachers in the RSA and the pre-service training of secondary school

Mathematics teachers at colleges of education under the control of the House of Representatives.

Chapter 2 contains a review of the nature and value of Mathematics and Mathematics Education. Chapter 3 looks at Mathematics teacher education and includes discussions of the professional life of Mathematics teachers, pre-service training of secondary school Mathematics teachers and in-service support for Mathematics teachers.

The research design is discussed in Chapter 4. Chapter 5 discusses the results of the survey. My findings and recommendations are dealt with in Chapter 6, which also includes the conclusion. The appendices contain the three questionnaires, the HDE (Secondary) Mathematics syllabus and a list of library books available at the colleges of education.

CHAPTER ONE

THE PROBLEM AREA

1.1 INTRODUCTION

This study is based on the pre-service training of secondary school Mathematics teachers at colleges of education under the control of the House of Representatives. In the Republic of South Africa (RSA) education for the different population groups is regarded as a so called 'own affair', each with its own Administration and Minister of Education.

This chapter will give a brief background to the education system for the population group classified as 'Coloured', as well as a historical background to the pre-service training of 'Coloured' teachers. In this chapter I will also be looking at the structure of the pre-service courses for secondary school Mathematics teachers at the relevant colleges.

According to the National Education Policy Amendment Act (Act No.73 of 1969) the training of teachers for the secondary school was to be solely the function of the universities as from 01 January 1976. Yet colleges of education for the

'Coloured' population group are presently training teachers for the secondary school. Because of this situation I would like to investigate the state of the pre-service training of secondary school Mathematics teachers at these colleges of education. The increasing demand for secondary school Mathematics teachers, especially for 'Coloured' pupils, could result in these colleges of education playing an even greater role.

1.2 THE TRAINING OF SECONDARY SCHOOL TEACHERS IN THE REPUBLIC OF SOUTH AFRICA: THE STATUS QUO

In November 1968 a report on the training of 'White' teachers in the RSA was prepared by a commission of enquiry under the chairmanship of Dr. J.S. Gericke and was laid before the Minister of National Education. One of the most important recommendations of the commission in this report was that the training of all secondary school teachers, except in the case of a few practical subjects, should be the responsibility of the universities. The provincial colleges of education should then be responsible only for the training of primary school teachers, but this too should be in close co-operation with the universities.

The recommendations of the Gericke Commission were accepted and placed on the Statute Book in 1969 as the National

Education Policy Amendment Act, Number 73, by the Parliament of the RSA. In order to carry out the provisions of the new Education Act, No.73 of 1969, the Minister of National Education subsequently ordained by way of Notice 1103 in the Government Gazette dated 10 July 1970 that all secondary school training courses, as were then being offered by the provincial colleges of education, should be terminated by 31 December 1975 [Behr 1971].

The new Education Act (Act No.73 of 1969) was primarily aimed at reorganizing the training of secondary school teachers so that it is in this field that the greatest change has been implemented. Presently only primary teachers are trained at colleges of education for 'White' persons. One of the greatest problems that arose as a result of this change was that of training student teachers who do not have full matriculation exemption. Such students had previously been admitted to the provincial colleges of education and had qualified for a Secondary School Teacher's Diploma. The universities, however, have always insisted on full matriculation exemption as the minimum requirement for entry into any of their faculties. The admittance of non-matriculation exemption students posed a problem situation, as the new Education Act was aimed at raising the standard of secondary teacher training by stipulating that

the duration of the training had to be not less than four years, and that a minimum of 8 degree courses had to be passed as laid down in the November 1972 Revised Edition of the "Criteria for the Evaluation of South African Qualifications for Purposes of Employment in Education."

There were two possible solutions to the above-mentioned problem. The first was to admit non-matriculation exemption students and provide courses for them at a less strenuous tempo than the usual degree courses. The second solution was to simply admit the non-matriculation exemption students and let them attempt the degree courses as provided by the universities, but this would result in a high failure rate in especially Mathematics and other science courses, which would in turn result in further aggravating the shortage of teachers in these subjects.

The aforementioned criteria make provision for three different types of teacher training courses, namely, a four-year non-degree course, a Bachelor's degree and post-graduate diploma four-year combination, as well as a four-year Bachelor's degree in Education. Before the passing of the National Education Policy Amendment Act (Act No.73 of 1969) all the universities in the RSA were, to a lesser or greater extent, active in the training of secondary school teachers. The universities have subsequently extended their

teacher training courses considerably by also offering a four-year non-degree teacher training course for aspirant secondary school teachers who do not have a matriculation exemption [Van Der Berg 1976].

The universities have been given a comparatively free hand in the choice of syllabi for the training of secondary school teachers. At a few universities the practice is to combine the Mathematics and the methods lectures in a single course, while at other universities they are treated separately.

1.3 PRE-SERVICE TRAINING OF SECONDARY SCHOOL MATHEMATICS TEACHERS AT COLLEGES OF EDUCATION ADMINISTERED BY THE HOUSE OF REPRESENTATIVES

1.3.1 The education system for persons of the 'Coloured' population group

During 1984 the South African Constitution was changed to allow the 'Coloured' and Indian population groups to take part in the election of the Parliament of the RSA. A tri-cameral parliament (consisting of three houses) was established with the House of Representatives administering the affairs specifically concerned with the 'Coloured' population group.

According to the new Constitution and the government's education policy as stated in its White Paper (1983) and

further explained in a 1985 publication of the Department of National Education, "The Structure and Operation of the South African Educational System", the formulation and execution of policy for all education in the RSA is the function of the central umbrella Department of National Education under the Minister of National Education.

The actual provision and administration of education is decentralized into substructures, known as Executive Departments of Education, each headed by a Minister of Education and Culture, a Director-general and an Executive Director. Each of these substructures serves a particular population group. It manages the schools, colleges of education and other institutions in which pupils and students of that group are educated. This new system has done away with the system of provincial authorities and has instead created a new type of decentralization of the administrative aspects of education on a population group and regional basis.

The challenge of the new system is to provide equal educational opportunities and education of an equal quality to all population groups. Harmse [1987] listed two factors that contribute towards this undertaking of providing equal education for the population group classified as 'Coloured'. Firstly, the accommodation facilities available at the

schools were to a great extent inadequate and wiping out this accommodation backlog was a priority which would require time. A second major problem was the inadequate training of serving teachers. The upgrading of their work would necessitate additional in-service training. Linked to this was the unavailability of suitable recruits to be trained as teachers, to staff the secondary schools especially.

Another challenge yet to be met, at the national level, is the co-ordination of the activities of the various racially segregated Education Departments and the promotion of co-operation, thus avoiding unnecessary duplication of services, research and facilities.

1.3.2 **Historical background to the pre-service training of teachers**

In the RSA as elsewhere in developing countries, the children requiring education vastly outnumber teachers who can provide the required education. In the past the ability to read and write was often the only qualification required for teachers. At first schools for the local inhabitants were the concern of religious denominations and missionaries themselves catered for the education of their converts.

During those earlier times, teachers were trained in the

classrooms, mostly by the missionaries themselves. Later training schools were established where pupils who had some formal education were trained to teach the younger pupils. Some of these training schools were also established by the state. The first such school was established in 1838 in Cape Town.

By 1964 there were a total of 8 training schools for 'Coloured' teachers in the RSA. These training schools enrolled pupils who had passed standard 8 for a two year training period. In 1977 the duration of this course was extended to three years and led to the Junior Primary Teachers' Certificate. This course was completely phased out in 1983, because it was regarded as inadequate training for teachers.

In 1941 the first training college for training of 'Coloured' teachers at the post-Senior Certificate level was established in Cape Town, offering the Primary Teachers' Certificate (PTC). By 1964 there were 4 training colleges; they also offered the three-year Primary Teachers' Diploma (PTD). Since 1980 these colleges have been known as colleges of education. At present there are 12 colleges of education - one in the Transvaal, one in Natal and 10 in the Cape Province.

In view of the dire need for qualified teachers for the secondary schools the PTD course was revised in 1979 in spite of the fact that teacher training for the secondary schools was considered to be the function of the universities and not of the Education Department. Differentiated training was also introduced for the first time in colleges of education by allowing certain students to specialise in certain subjects at a more advanced level, with the view of teaching in the secondary school. The practice of utilizing micro-teaching and closed circuit television in teaching practice was also introduced in 1979.

In a publication compiled by the Education Bureau, Harmse [1987] states that due to poor co-ordination between the departments of education and the universities, as well as a lack of proper planning and a systematic training programme, the provision of teachers for the secondary schools was mainly left to chance. The increase in the secondary school population during the seventies and eighties aggravated the problem and the supply of teachers did not keep up with this population expansion, resulting in the fact that teachers trained for the primary school were called upon to occupy posts in secondary schools. In 1985 only 27,8% of the secondary school teachers at 'Coloured' schools were adequately trained [Harmse 1987].

In 1982 a new system of teacher training at colleges of education was introduced at post-Senior Certificate level with a duration of not less than three years. This system made provision for the introduction of a four-year diploma course. The following courses are presently being offered at colleges of education administered by the House of Representatives:

- (a) Diploma in Education (Pre-primary) a three year course for the pre-primary phase. This course is offered at only one college of education.
- (b) Diploma in Education (Junior Primary) - a three year course for the junior primary phase.
- (c) Diploma in Education (Senior Primary) - a three year course for the senior primary classes.
- (d) Diploma in Education (Practical Subjects) - this diploma qualifies teachers to teach the practical subjects they specialised in at primary and secondary school level as well as certain academic subjects at the primary and junior secondary school level.
- (e) Higher Diploma in Education (Secondary) - a four year course in academic subjects for teachers who wish to teach in the junior secondary classes.
- (f) Higher Diploma in Education (Junior Primary / Senior Primary / Practical Subjects) - a one year course

following the three year course of the Diploma in Education.

The HDE (Secondary) course is at present only being offered at five of the colleges of education. In the light of available statistics the department annually decides which courses are to be offered at the different colleges of education. The entrance requirements for the HDE (Secondary) course as well as the number of students that qualify at the end of their first year plays a major role in determining whether the HDE (Secondary) course will be offered at a particular college.

1.3.3 The Curriculum for the HDE (Secondary) course

The HDE (Secondary) course stretches over four years. The time allocated for each subject is indicated in brackets below:

1.3.3.1 Curriculum for the first year:

Both Official Languages (30%), Class Teaching (5%)

Pedagogics(7,5%), Mathematics(10%), Science(7,5%),

Geography(7,5%), History(7,5%)

Teaching Aids and Speech Training(5%), Scripture(5%)

THREE of the following: Art, Music, Handicraft, Needlework or Physical Education (15%).

1.3.3.2 Curriculum for the second year:

Both Official Languages (30%), Class Teaching(7,5%),
 Pedagogics(12,5%), Teaching Aids and Speech Training(5%)
 THREE of the following: Mathematics, Biology, Physical
 Science, Geography or History (45%).

1.3.3.3 Curriculum for the third year:

Both Official Languages (35%), Class Teaching(10%)
 Pedagogics(15%), Teaching Aids and Speech Training(5%)
 TWO of the following: Mathematics, Biology, Physical
 Science, Geography or History (35%).

1.3.3.4 Curriculum for the fourth year:

Pedagogics(20%), Class teaching(7,5%)
 TWO of the following subjects which were passed in the third
 year: Official Language 1, Official Language 2, Mathematics,
 Biology, Physical Science, Geography or History (40%)
 ONE of the following subjects discontinued after the second
 year: Mathematics, Biology, Physical Science, Geography or
 History (15%), Individual Study(7,5%).

Subject Didactics for all the school subjects is included in
 the different syllabi, but only examined from the second year
 of study. Refer to Appendix D for the content of the

Mathematics syllabi for the HDE (Secondary) course as presently being offered at the colleges of education.

The number of lecturing periods per week allocated to the teaching of Mathematics for the four years of study is as follows:

	<u>Content</u>	<u>Method</u>	<u>Tutorials</u>	<u>TOTAL</u>
HDE 1	3		1	4
HDE 2	4	1	1	6
HDE 3	5	1	1	7
HDE 4	6	1	1	8

1.3.4 Entrance and pass requirements for the HDE (Secondary) course

Only candidates selected by the Department of Education and Culture are admitted to a college of education. Selection is subject to the requirements for admission and the need for teachers in a particular course of study is taken into account.

Only those candidates are admitted who are in possession of the Senior Certificate with:

- (a) passes in both official languages, one as First Language Higher Grade, obtaining at least 40%, and the

other at least as Second Language Higher Grade, obtaining at least 33,3%.

(b) passes in at least TWO of the following subjects of which at least one must be on the Higher Grade: Biology, Physical Science, Mathematics, Accounting, History, Geography, Biblical Studies, Woodwork, Needlework, Home Economics, Technical Drawing, Music, Art, a third language.

(c) passes in TWO other subjects.

Subjects which a student has not passed in the Senior Certificate either on the Higher or Standard Grade cannot be offered for the HDE (Secondary) course.

The number of students admitted to a college of education every year for the first year of the course is determined by the Department. The quota for a class in the first year of the course is thirty students.

At the ends of the first, second and third year of study internal examinations are conducted in all subjects. At the end of the fourth year of the course external question papers are provided for some subjects or sections of subjects, while an internal examination is set for the remainder of subjects or sections of subjects. Practical teaching examinations are conducted internally and moderated by the inspectorate of the

Department.

The requirements for proceeding to the following year of study and pass requirements are set out as follows:

A passmark is 50% throughout.

(a) First year:

In order to proceed to the second year of the course a candidate must achieve a passmark in the examination as a whole; achieve a passmark in his First Language; obtain at least 35% in the other language; obtain a passmark in Mathematics, Geography and History OR a passmark in Science and one other subject.

(b) Second year:

In order to proceed to the third year of study a candidate must achieve a passmark in the examination as a whole; both languages and a passmark in TWO academic subjects.

(c) Third year:

In order to proceed to the fourth year of the course a candidate must achieve a passmark in the examination as a whole; passmarks in both languages; obtain a passmark in ONE academic subject and a subminimum of 40% in the other academic subject.

(d) Fourth year:

In order to pass the final examination in the fourth year of the HDE (Secondary) course a candidate must at least obtain: a passmark in the examination as a whole; a passmark in Class Teaching; passmarks in THREE subjects and at least 40% in the remaining subject.

A candidate who does not obtain at least a passmark in the examination as a whole or fails in more than TWO subjects must repeat the fourth year of the course in its entirety.

1.3.5 Practical training

The practical training of the student is an important facet of his training and takes place in collaboration with neighbouring schools under the control of the Department. Time is allocated weekly on the college timetable for guidance, demonstration, micro-teaching and criticism lessons. This form of practical training is known as Class Teaching.

Periodically students visit neighbouring schools for a period of continuous Practice Teaching. During this period the student conducts at least half of the lessons to a class

under the guidance and supervision of the class teacher. The students are also visited by lecturers who evaluate their lessons. Marks awarded for lessons form the basis of the student's mark for Class Teaching.

Time allocations for the two forms of practical training for the different years of the course are indicated in the following table:

<u>YEAR</u>	<u>CLASS TEACHING</u>	<u>PRACTICE TEACHING</u>
HDE1	2 periods/week	3 weeks
HDE2	3 periods/week	5 weeks
HDE3	4 periods/week	5 weeks
HDE4	4 periods/week	3 weeks

During the first semester the first year students normally do not teach, but observe demonstration lessons given by the senior students or by the lecturers themselves. In their first year the students do teaching practice in standards 1 to 4. From the second year of study the HDE (Secondary) students do teaching practice in the junior secondary standards, while in their fourth year they practice teach in the senior secondary standards.

CHAPTER TWO

MATHEMATICS EDUCATION

2.1 THE NATURE AND VALUE OF MATHEMATICS

When Plato wrote over the portal of his school:

" LET NO ONE IGNORANT OF GEOMETRY ENTER HERE "

he did not mean that questions relating to lines and surfaces would be discussed by his disciples. On the contrary, the topics to which he directed their attention were some of the deepest problems - social, political, moral - on which the mind could exercise itself. What had Geometry to do with these things? Simply this: That a man whose mind had not undergone a rigorous training in systematic thinking, and the art of drawing legitimate inferences from premises, was unfit to enter on discussion of these high topics; and that the sort of logical discipline which he needed was most likely to be obtained from Geometry - the only mathematical science which in Plato's time had been formulated and reduced to a system. At school we are expected to learn a good deal about topics like curves, angles, numbers and proportions, not

because these topics are necessarily related to the needs of our lives, but because in the very act of learning them we are likely to acquire that habit of steadfast and accurate thinking, which is indispensable to success in all pursuits of life.

In any discussion about proposed curricula, at any school level, Mathematics is always included. What is Mathematics, and why in spite of changing content and teaching aims, does it have this insistent claim when discussing curricula?

Any attempt to formulate a definition of Mathematics that would include all its attributes would be inadequate, because its nature is such that no single attribute can be isolated and some of its attributes can easily be overlooked or might not be known to the mathematicians of our time.

In my attempt I am going to look at some of the main characteristics of Mathematics, such as the part it plays in history and culture, its aesthetic value, the language of Mathematics, Mathematics as a tool in the changing world, the products and processes of Mathematics and the axiomatic, hierarchical structure of Mathematics.

2.1.1 Mathematics as part of history and culture

A study of the manner in which Mathematics evolved from primitive to modern forms can give us some perspective regarding its nature. All ancient cultures found it necessary to devise elementary counting symbols that were needed for the ability to communicate. Social pressures forced the invention of Arithmetic, which can still be regarded as one of man's greatest intellectual achievements. Today the cultural demands on Mathematics, in the form of problems posed by both the natural and social sciences, predominate in the so-called stimuli for Mathematical research. Until recent times the chief source was the natural sciences.

Babylonian Mathematics contained virtually no Geometry as we know it and its Algebra was verbal and proof consisted of empirical verification. Egyptian Mathematics was the chief source upon which the Greeks constructed their Mathematics. The Greeks brought Mathematics to a higher level of abstraction, the geometric rule of the Egyptians became a mathematical theorem, and proof became a matter of logical deduction. The axiomatic method as a research tool was begun by the Greeks. The contributions of the Arabs and Orientals resulted in the invention of a symbolic apparatus for Algebra

and from this a fusion of Algebra and Geometry was achieved. Early in the nineteenth century non-Euclidean Geometries were conceived by mathematicians like Gauss, Bolyai and Lobachevsky. These were important events as they resulted in the theory of relativity and the development of nuclear fusion. Mathematics was no longer bound by empirical considerations or by the compliance with the ordinances of some imaginary world. The axiomatic method shared in this metamorphosis. Without these developments Mathematics as we know it could hardly exist. Finally in the late nineteenth century a powerful tool for Mathematics in the form of the theory of Sets was created by Cantor and necessitated the invention of new proof principles. In no period of the past has there been so much research in Mathematics as there is today.

Mathematics is a unique discipline in not renouncing its past insights, but rather developing new insights out of what has gone before:

"In most sciences one generation tears down what another has built and what one has established another undoes. In Mathematics alone each generation builds a new story to the old structure."

HERMANN HANKEL 1884.
in MORITZ 1942, p78.

The history of Mathematics is filled with instances of mathematical concepts which were subsequently applied to other sciences. Mathematics gradually added concepts of its own to the world of reality, so that the domain of its applications included not only the physical environment, but also the cultural environment. Television, radio, air travel and so many other things would not have been possible without Mathematics. These phenomena bear witness to the cultural and scientific nature of Mathematics. A major function of culture is to control man's environment. No mathematician can escape his cultural environment, which is a participant in the evolution of Mathematics. Every mathematician must recognize that whatever he is engaged in, it is connected with the culture of his time.

Since the history of Mathematics is essentially a report on the discovery or invention of theorems and the gradual evolution or change of certain concepts, De Villiers [1986] suggested that a historical conception should be an important prerequisite to the development of a sound perspective on Mathematics. Prospective secondary school Mathematics teachers should be able to describe the historical and cultural significance of some of the mathematical principles taught at secondary level.

2.1.2 Mathematics as a fine art

The beautiful has its place in Mathematics as elsewhere. Although mathematical forms are increasingly used in graphic art it is really in the gaining of aesthetic satisfaction in Mathematics itself that one thinks of Mathematics as an art. "This aesthetic satisfaction can only be gained by actually doing Mathematics" [Noble 1985, p2].

Mathematics also has its triumphs of creative imagination, its beautiful theorems, its proofs and processes whose perfection of form has made them classic. Just as the musician is able to form an acoustic image of a composition which he has never played by merely looking at its score, so the equation of a curve, which he has never seen, furnishes the mathematician with a complete picture of its course. [Moritz 1942]

Bertrand Russell in his Philosophical Essays has so aptly stated that:

"Mathematics possesses not only truth, but supreme beauty - a beauty so austere, like that of sculpture without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show."

in MORITZ 1942, p182.

Mathematics has its beauties of its own, a symmetry and proportion in its results, a lack of superfluity and an exact adaptation of means to an end. These beauties can and should be exemplified to children, but not overdone or insisted upon and prospective Mathematics teachers must be exposed to ways of achieving this.

The fascination of Mathematics is the same as the fascination of exploration, except that the discoveries are made in the realm of ideas rather than in that of physical space. It is not possible for our pupils to rediscover the whole of Mathematics for themselves, but the pleasure can still be experienced under guided discovery. For children to appreciate the beauty in Mathematics they must be exposed to the elegant aspects as well as the drudgery of computation. Prospective secondary school Mathematics teachers must be able to identify resource materials that may be used to develop concepts and to generate enthusiasm for Mathematics in pupils.

2.1.3 Mathematics as a language

"Mathematical language is not only the simplest and the most easily understood of any, but also the shortest."

H.L. BROUGHAM
in MORITZ 1942, p194.

Mathematics is a concise, yet elegant language. Its value as a language is that it enables the mathematician to communicate his ideas in an unambiguous way and at the same time helps him to organize his ideas.

Before the introduction of the Arabic notation, multiplication was difficult, and division of integers called into play the highest mathematical faculties. Probably nothing in the modern world would have astonished a Greek mathematician more than to learn that under the influence of compulsory education the whole population of Western Europe could perform the operation of division. Our modern power of easy reckoning with decimal fractions is the most miraculous result of a perfect notation.

The language of Mathematics is objective and universal with its own vocabulary and syntax. It is consistent, clear and lacks ambiguity. The language is international for the symbols employed have acceptance in many countries whose languages differ. As Scopes so aptly states, "an effective symbolism frees the mind to concentrate on essentials" [Scopes 1973, p16].

The business of translation is fundamental to much of the utility of Mathematics in the real world. A function of language, besides conveying meaning, is persuasion; nothing

is more persuasive than logical argument.

The way in which Mathematics forces us to clarify our ideas and to use language with care is one of the more powerful arguments for its place in the school curriculum. Marjoram [1974] is of the opinion that if the study of Mathematics does not induce in the learner some objective traits and linguistic concern, one may question how effectively it has been taught. But language is not enough, and it later becomes too cumbersome for some of the mathematical ideas we wish to express.

We never relinquish the use of language, but what really happens is that we use it in natural conjunction with more symbolic means of communication. The lack of an effective symbolism in Greek Mathematics finally prevented further progress in their Mathematics. Prospective secondary school Mathematics teachers must thus be able to use the mathematical terms and symbols appropriate to the secondary school level.

2.1.4 Mathematics as a tool in the changing world

"How can it be that Mathematics, a product of the human thought, independent of experience, is so admirably adapted to the objects of reality?"

ALBERT EINSTEIN

Historically, intellectually and practically, Mathematics is primarily man's finest creation for the investigation of nature. It is valuable because of its contributions to the mastery and understanding of the physical world.

Insofar that it is a study of space and quantity, Mathematics directly supplies information about aspects of the physical world. It enables the various sciences to draw implications of their observational and experimental findings. Science has become a collection of mathematical theorems adorned with a few physical facts. Its concepts and methods of obtaining knowledge have been most effective in representing and investigating the motions of the heavenly bodies; the motion of objects; the phenomena of sound, light, heat, electricity, wave structure, structure of matter, chemical reactions, structure of biological organisms and various other scientific phenomena. The practical advantage of studying Mathematics is to satisfy man's intellectual curiosity.

Mathematics is devoted to the study of the physical world. Actually it studies certain abstract concepts, the most elementary of which are derived from physical objects. Physical straight lines have thickness, colour and often rigidity. The mathematical straight line has none of these properties. Likewise, other geometrical forms and the concepts of arithmetic are abstractions of certain properties

of the physical object. On the basis of such abstractions, Mathematics creates others that are even more remote from anything real. Negative numbers, equations, functions, integrals and others are abstractions built upon abstractions.

The concepts, ideas, methods of reasoning and the ideals which have been pursued were fashioned by human minds. The mind plays a part in the creation of mathematical concepts and in determining the direction that reasoning shall pursue, but the mind does not function independently of the world outside. Unfortunately the relationship of Mathematics to nature is not present in the dry and technique-soaked textbooks used in our schools.

2.1.5 Mathematics as products and processes

Mathematics also has a twofold character, namely it is a "verb" as well as a "noun". What do we obtain when we use Mathematics? What do we do when we "mathematize"? Processes are developed from Mathematics that in turn yield products.

Postulates, theorems, undefined and defined concepts are some of the products of Mathematics. A concept is a classification of objects, object-properties, or events by

the process of abstraction. Postulates are statements accepted without proof, which together with defined and undefined concepts are used to prove theorems by means of deductive logic. Theorems are remarkable products of Mathematics. Given the same set of postulates and concepts, they are statements that are true for all time. Mathematical models are also products of Mathematics. A mathematical model refers to a set of mathematical terms and statements which appear to be an idealized reflection of the data or events in the physical world. Much of the Mathematics taught at school would be more meaningful to pupils if the concept of a mathematical model were introduced.

The consideration of mathematical models leads us to the second aspect of Mathematics in answer to the question: What do mathematicians do? Remember that Mathematics is also a "verb". Some of the deductive processes of Mathematics are: assuming, computing, hypothesizing and proving. Deductive reasoning is the method of proof used in Mathematics. Testing, conjecturing and generalizing are some of the inductive processes of Mathematics. Generalizing is a valuable tool of the scientists, as is idealizing, but the processes most characteristic of the mathematician are those which result in a mathematical system. Inductive reasoning is an excellent way to help pupils see for themselves some of

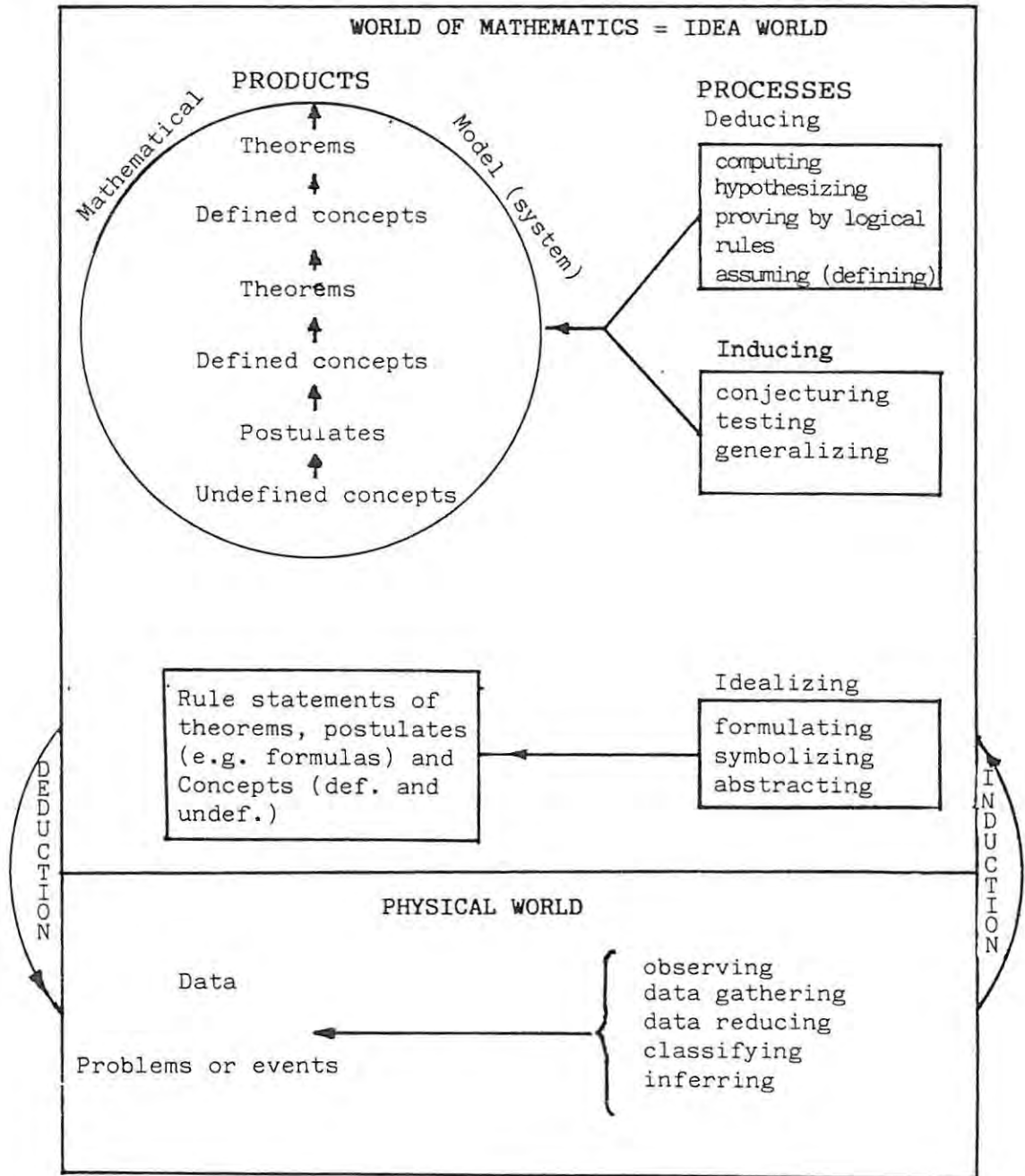
the rules and concepts of Mathematics. Abstracting and symbolizing are two of the idealizing processes of Mathematics.

A synthesis exists between the product and process aspects of Mathematics. A schematic thought model of Mathematics as proposed by M.A. Farrell and W.A. Farmer as shown in Fig.1 is a synthesis of the process/product views of Mathematics in relation to the physical and idea worlds. [Farrell 1980, p87]

Each of the lines and shapes in the schema is there to convey an aspect of the thought model of Mathematics. The curved arrows between the physical and idea worlds are curved toward one another to suggest a cyclic movement in and out of the two worlds. The dynamic nature of Mathematics is conveyed by the chain of arrows in the circular shape.

Although the concepts and assumptions which form the basis for every mathematical system are inventions of the human mind, they are not the gibberish which might be assembled by a robot, because there is rationale behind each such product of Mathematics. The rationale can take the form of a motivating force, a need in the physical world or a desire for simplification.

FIG.1: A SCHEMATIC THOUGHT MODEL OF MATHEMATICS



2.1.6 Mathematics as an axiomatic, hierarchical structure

A striking feature of Mathematics is the high degree of abstraction to which it aspires. An important tool in the abstraction process is the axiomatic method. A system of axioms is merely a system of rules which has to be used in the derivation of new theorems.

In the past it was falsely believed that axioms are "self-evident truths" derived from physical experience. The modern belief is summed up by Hilton when he states that:

"Axioms are postulates about undefined entities and not self-evident truths about actual objects."

in DE VILLIERS 1986, p40.

E.B. Wilson expresses the same thought differently by stating:

"The familiar definition: An Axiom is a self-evident truth, means if it means anything, that the proposition which we call an axiom has been approved by us in the light of experience and intuition. In this sense Mathematics has no axioms, for Mathematics is a formal subject over which formal not material implications reign."

in MORITZ 1942, p351.

In free artistic play, guided only by a sense for mathematical values, one can modify, omit and add individual axioms or create or examine entirely new systems of axioms. Axioms play an important role in the aesthetic side of Mathematics.

2.1.7 Summary

To summarize, we have now seen how Mathematics has come to be regarded as a language - a means of communication increasingly used by economists, geographers, businessmen and others; as a training ground in which objectives can be attained; as a tool whose value increases rapidly; and as a subject worthy of study for its own sake, capable of giving pleasure and creating interest. When designing curricula it will be necessary to decide what weight has to be given to each of these objectives and how we are to interpret the terms "language", "training ground", "tool" and "subject".

A recent study by Thompson [1985] has indicated that a teacher's conception of the nature of Mathematics may play a significant role in his teaching practice.

When considering why we should teach Mathematics we often forget that education has wider aims than are apparent from

the school timetable. When considering the role of Mathematics in the curriculum it is important to remember that our primary concern should be the improvement of the overall education of the child and that a teacher's job is to educate not merely instruct.

Without a sound conception of the nature of Mathematics and its part in man's culture and society, it is impossible to formulate pedagogically sound teaching aims to justify the place of Mathematics in the general education of children. Prospective secondary school Mathematics teachers must thus be shown how to identify different aspects of the philosophy and nature of Mathematics illustrated in the secondary school syllabi.

2.2 MATHEMATICS EDUCATION

2.2.1 The role of Mathematics Education

Great and rapid changes in Mathematics courses are taking place in schools, colleges and universities throughout the world today. These developments have resulted from a re-evaluation of the content and purposes of Mathematics teaching. In recent years the subject has expanded dramatically in its content and applications, leading to a

situation in which there is considerable difficulty in making the selection of material to be included in any curriculum. Knowledge and skills not only from Mathematics are needed to discuss, plan and implement such changes. This has given rise to the new discipline "Mathematics Education".

The Mathematics Section of the British Association of Teachers in Colleges and Departments of Education (1970) define Mathematics Education as:

"A study of aspects of the nature and history of Mathematics and the psychology of its learning and teaching which contribute to the teacher's understanding of his work with children, together with a study and analysis of mathematical curricula for schools, the principles underlying their development and the practice of their use in the classroom."

in WAIN 1978, p2.

Griffiths and Howson [1974] see the nature of Mathematics, nature of society, nature of children and the nature of teachers as four important factors essential for producing a curriculum. Neglect of any of these factors is likely to produce a curriculum that will be ill-balanced, irrelevant and impossible to implement. Mathematics Education being a practical activity and not merely a theoretical study must then of necessity draw upon the knowledge of other disciplines.

There is an increasing awareness of the need to consider the role of Mathematics Education and the difficulties of designing Mathematics curricula. This is also seen in the establishment of an international congress on mathematical education. The first International Congress on Mathematical Education (ICME 1) was held in Lyon, France, in 1969; the second in Exeter, England, in 1972; the third in Karlsruhe, West Germany, in 1976; the fourth in Berkley, USA, in 1980; the fifth in Adelaide, Australia, in 1984 and ICME 6 will be held in Budapest, Hungary, during 1988. The success of these congresses has shown the number of people around the world involved in the study of mathematical education at all levels.

Mathematics Education is essentially concerned with the problem of deciding what Mathematics should be communicated to the next generation to satisfy their individual needs as well as the needs of the subject itself and the needs of society.

Elizabeth Fennema [1981] summarizes the main areas in which Mathematics Education research can make contributions as follows:

- (a) description of what has been,
- (b) description of what is, and

(c) description of what is possible.

2.2.2 Some aspects of Mathematics Education

Firstly we are concerned with the nature of Mathematics as an academic discipline and its importance in determining how we should set about to communicate it effectively to the next generation. We have to bear in mind the need to ensure that Mathematics retains for everyone a coherence that reflects its current developments as well as the need to train the future specialist mathematicians. The past century has seen a dramatic development in the internal organization of the subject itself. It is vital to take note of the changes occurring in the subject in order to be aware of what should be considered relevant within the subject at all levels of teaching. Even more recently there has been a dramatic increase in the range of applications of the subject.

Secondly, while the subject matter is of immense importance in decisions about mathematical education we also have to consider the nature of the people involved in Mathematics. This sociological aspect of Mathematics is important as the place in society of professionally trained mathematicians has radically changed. The steadily increasing demand for mathematical skills in industry and commerce, in research and

in' an ever widening range of subjects is witness to its importance. Once one looks at the people involved in mathematical activity one is concerned with a sociological viewpoint: The important people in the activity of mathematical education are the teachers who are engaged in communicating the subject to their pupils and students. The way they are trained, the skills they utilize, the attitudes they have towards the subject are all crucial factors in this communication process. The quality and quantity of the teaching force may be a far more important factor in the decision making process about the curriculum than is often believed. The consequences that this sociological aspect has for the training of Mathematics teachers are profound.

Thirdly we have to consider the psychological aspects of Mathematics as the Psychology of Mathematics is becoming an increasingly important determinant of curricula development. It is assumed by Dienes [1973] that in order to learn Mathematics we require a battery of skills of a particular type and that the contribution of psychologists is to enable the teacher to most effectively allow the pupil to acquire those skills. He also sees the task of the psychologists as one of identifying these skills and helping the teacher in transmitting them through the now less important subject material. Mathematics then becomes an intellectual activity

aimed at developing abilities such as abstractions, generalizations, symbolizations and proof. The mathematical content of the learning process becomes to some extent subservient to the development of these abilities.

A fourth aspect of mathematical education is the process of evaluation and assessment of curricula and pupils at the ends of courses. Examinations have a role to play besides the grading and classifying of pupils as they can help the teacher by showing him where his teaching has failed or succeeded. Evaluative processes will assist the teacher to check whether or not objectives have been attained. The requirements of examinations should not be the determinants of what is taught, but assessment methods should reflect the objectives of the course just as much as the content and teaching style that has been adopted.

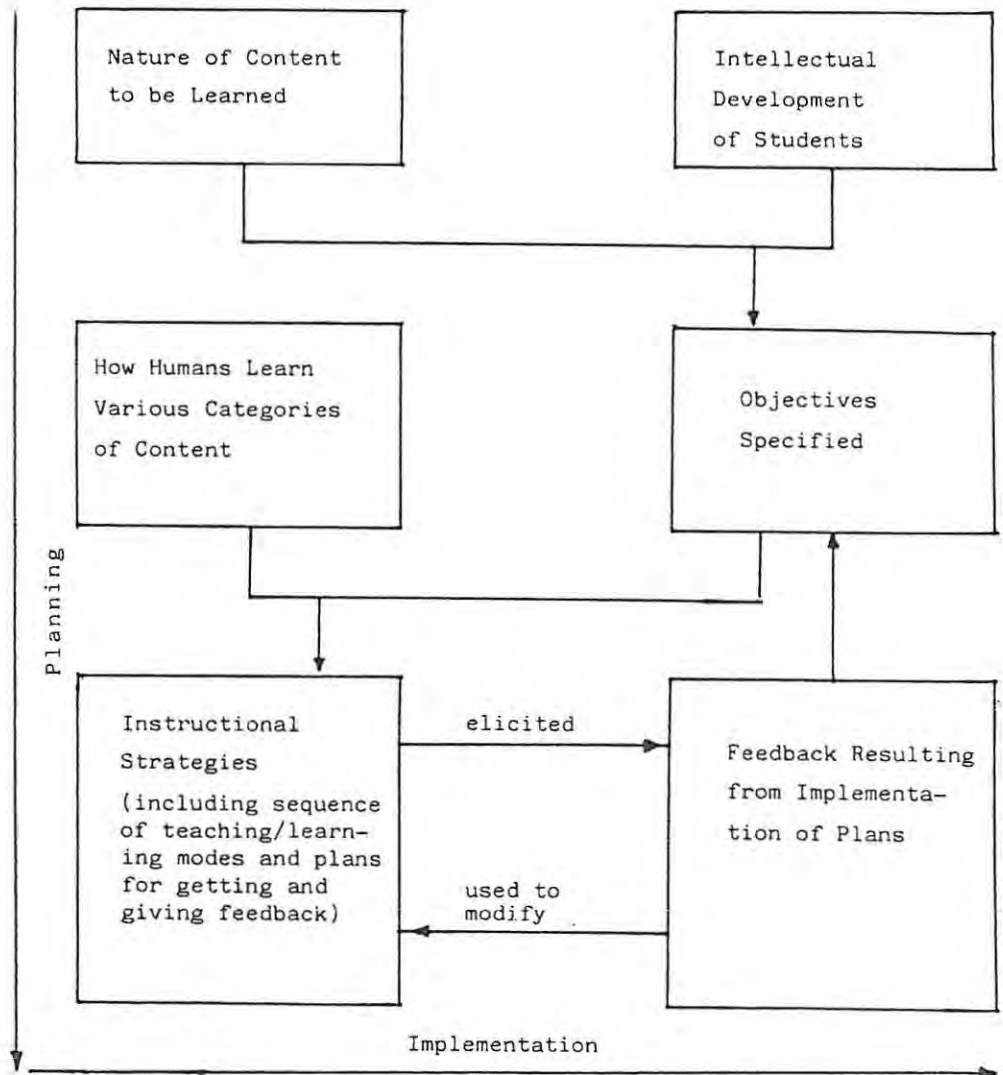
2.2.3 A model for the process of teaching Mathematics

The process of teaching Mathematics is schematically represented by M.A. Farrell and W.A. Farmer as illustrated in Fig.2.

The inter-dependence and cyclical nature of these six aspects of the process is indicated by the direction of the arrows.

In teaching, the most attention is generally given to the aspect "Instructional Strategies", but with limited effectiveness if the other factors and their interplay are not also considered.

FIG.2: THE PROCESS OF TEACHING MATHEMATICS



Note that the coupled aspects "Nature of Content to be Learned" and "Intellectual Development of Students" form the bases for the aspect "Objectives Specified". In any systematic approach to teaching it is vital to formulate clear objectives that closely match both the students they are presumed to affect and the subject matter content they are claimed to represent. As the rest of the model depicts, these objectives will be used to design "Instructional Strategies", guide the collection of "Feedback" and then be reassessed in the light of the resultant learning. Thus the teacher's comprehension of the subject matter of Mathematics will have profound effects on all aspects of teaching.

The position of the aspect "Objectives Specified" as an output based on analysis of the content of Mathematics and analysis of the "Intellectual Development of Students" is a reminder that these two aspects of planning are precursors to defining "where you are going".

Also note the two feedback loops depicted in the schematic. One leads to and from the key aspect "Instructional Strategies" which is the summation of the planning dimension of the teaching model. Decisions on what worked and didn't work and the reasons why, must be made intelligently on the basis of "Feedback" results. A positive classroom atmosphere depends on careful planning and consistent response to

feedback during the class period. The feedback loop to "Objectives Specified" points to the need for a firm data base upon which to judge the degree to which important objectives have been realized. Initial objectives may need to be revised in the light of this experience.

CHAPTER THREE

MATHEMATICS TEACHER EDUCATION

3.1 ASPECTS OF THE PROFESSIONAL LIFE OF MATHEMATICS TEACHERS

As a result of modern communication techniques teachers of Mathematics can nowadays be found in all corners of the world, teaching Mathematics to children and adults, to the illiterate and the learned, to the eager and the reluctant.

Griffiths and Howson [1974] are of the opinion that the potential of an educational system is directly related to the ability of its teachers, and the rate at which change can be assimilated into an educational system depends greatly on the teacher. Dr Beeby postulated that an educational system in developing countries must of necessity pass through four stages as described by the following model [Griffiths and Howson 1974, p63]:

Stage 1: The "Dame school" stage: at which teachers are neither trained nor educated.

Stage 2: The stage of "formalism": at which the teachers are trained, but poorly educated.

Stage 3: The stage of "transition": at which the teachers are trained and better educated, but still lacking full professional competence.

Stage 4: The stage of "meaning": at which teachers are well trained and well educated.

Beeby's hypothesis that it is impossible to omit any of these stages, has far reaching implications for developing countries like the RSA where teaching is generally at Stage 2. The findings of this study have also shown that the system of Mathematics teacher education at colleges of education under the control of the House of Representatives is at most at Stage 2. To move from Stage 2 to Stage 3 requires better education and more professional awareness; not more training. Steps are constantly being taken in an attempt to ensure that teachers entering the profession are better trained and better educated than their predecessors.

During his professional life a Mathematics teacher may influence the attitudes towards Mathematics of thousands of young people and decisively affect many of their career choices. The shortage of well-qualified Mathematics teachers in especially secondary schools has increased considerably both as a result of the increasing number of pupils in schools and also of the increasing demand for mathematicians in industry and commerce. Harmse [1987] in his research on

the education for 'Coloureds' in the RSA, has shown that during the period 1970 to 1985 there has been an increase of 250,75% in the number of secondary school pupils and an increase of 318% in the number of secondary school teachers.

It is an extremely difficult task to determine the shortage of teachers in any subject: "officially" there is no shortage, because all the classes in every school have teachers standing in front of them. The problem is that many teachers are not trained for teaching the subjects they are called upon to teach. An unhealthy situation presently exists in most secondary schools for 'Coloureds' in the RSA where teachers trained for the primary school are teaching in secondary schools. Harmse [1987] in his study found that during 1985, 11,6% of the secondary school teachers had no professional training, while 51,83% of the secondary school teachers had been trained for the primary school. There is no evidence to suggest that the situation has improved since 1985. Not only are such teachers not suitably trained for this secondary school work, but they do not contribute to the increase of mathematical expertise which is so badly needed in primary schools.

There can be no doubt that the most important resource for good Mathematics teaching is an adequate supply of competent Mathematics teachers trained by equally competent trainers.

3.1.1 Qualities of professional Mathematics teachers

What is a professional Mathematics teacher? One definition is that a professional Mathematics teacher is simply one who is a good teacher. But what is a good teacher? J.C. Egsgard, in a paper delivered at ICME4 (1980), defines a good teacher as follows:

"A good teacher of Mathematics is one who uses his knowledge and love of Mathematics as well as his love and respect for his students to lead students to enjoy the study of Mathematics."

JOHN EGSGARD
IN ZWENG 1983, pl44.

Egsgard says nothing about the student being successful, because he believes that a student who enjoys the study of Mathematics will be successful. According to his definition it is only necessary to discover the attitude of the students of a person to determine whether or not a person is a good teacher of Mathematics.

In a draft policy document on Mathematical Education in South African schools (1981) the Mathematical Association of South Africa (MASA) found that professional teachers of Mathematics should possess at least the following qualities [Nero 1981]:

- (a) A wide enough background of Mathematics to encompass the range of contents, activities and meanings dealt with in present and future curricula for Mathematics. This background should facilitate a full grasp of Mathematics in education.
- (b) A deep enough grasp of some areas of Mathematics and applied Mathematics to promote some understanding of the dynamic nature of Mathematics.
- (c) A thorough knowledge and understanding of strategies and techniques that may be used in the teaching of Mathematics. Proficiency in the utilization of these alternatives including the ability to make sensible choices for the purpose of dealing with specific contents, objectives, pupils and conditions.
- (d) Proficiency in the design and production of suitable curriculum material; the interpretation of given syllabi; identification and remediation of problems of both mathematical and attitudinal character which may be experienced by pupils with respect to Mathematics.

J.H. Webb [1985] in an address delivered at the Symposium on the Content of Mathematics Courses for Prospective Teachers (1984) insisted that Mathematics teachers must be mathematicians, because he supports the view of Hilary Shuard

that more highly trained mathematicians are more able to analyse the possibilities inherent in a situation which their pupils are studying. Mathematicians are able to call on a range of knowledge which helps them both to recognize the importance of the concepts their pupils are developing and to analyse the mathematical difficulties they find.

These demands might seem to be extreme considering the existing shortages of Mathematics teachers, but it would be foolish to limit provisions for professional growth of those teachers that may benefit from such provisions because there are teachers functioning on lower levels. To raise the level of competence of all Mathematics teachers to the qualities mentioned above, it is necessary to implement short-term and long-term measures, even if it might take decades to accomplish. Considering Egsgard's definition of a good Mathematics teacher it seems a pity that the requirement that a teacher of Mathematics must enjoy and love Mathematics has not been included in the above qualities as proposed by MASA.

We would certainly like to have teachers who know Mathematics in considerable depth; who are comfortable with the role of Mathematics in society; who understand and communicate with pupils; who can ably perform the task in the classroom; who will lead their pupils to goals of independence and self-esteem and who will provide moral and intellectual

models for their pupils. Most teachers will not possess all of these characteristics of a master teacher, but should aim for the best that their individual personalities allow them to achieve.

3.1.2 Phases of the professional life of Mathematics teachers

In the past, even in such illustrious nations as Britain and America, many teachers entered the profession without any professional training. Unfortunately this is still the case here in the RSA. The traditional idea of the task of the Mathematics teacher was that he was to pass his own knowledge of Mathematics on to a small section of the population who were selected to receive an academic education. The tools of the Mathematics teacher were basically the blackboard and textbook and he operated by demonstrating techniques, giving proofs and setting exercises. This picture of the task of the Mathematics teacher has become totally outdated.

The Cockcroft Committee in their report (1982) on an Inquiry into the Teaching of Mathematics in Schools sees the three main tasks of Mathematics teachers as [Cockcroft 1982]:

- (a) Enabling each pupil to develop within his own capabilities the mathematical understanding and

skills required for adult life, for employment and further study.

- (b) Providing each pupil the opportunity to develop as far as possible his appreciation and enjoyment of Mathematics.
- (c) Creating the awareness in each pupil that Mathematics provides him with a powerful means of communication.

Programs for the training of Mathematics teachers should thus strive to equip prospective Mathematics teachers with those skills, and with understanding, thinking strategies and appreciations of Mathematics and the teaching thereof, thereby enabling them to practice effectively their profession.

Mathematics is in a very exposed position in the equality debate, as a subject where individual differences are particularly visible. Developments in the idea of the role of teachers have resulted in Mathematics teachers having a much broader concept of their professional life. Some see themselves first as teachers and secondly as Mathematics teachers, with others it is the other way round.

It is difficult to separate the teacher's professional life from the pre-service preparation for entry into teaching. The teacher's professional life has to be built on the

equipment of knowledge and skills with which the teacher enters the profession. Problems of teaching Mathematics stem directly from the fact that the knowledge and skills with which the teacher enters the profession are inadequate for the task that he is expected to perform. Few teachers start their teaching careers with sufficient psychological background to understand the problems of slow-learners, for example. They can therefore not devise suitable learning experiences for a wide range of pupil abilities. Pupils of average ability can also present problems to the inexperienced teacher and he may respond to the less able pupil by providing watered down courses.

Induction to the profession can be seen as the first phase of professional life. It is a time of adjustment and a search for solutions to problems that the new teacher might not have foreseen or with which he has not yet learned to cope. During this time of strain and self-testing the teachers need to be supported by more experienced teachers. The next phase is characterized by a need for continuing education. Two main aspects of this phase are staff development and further professional study, where the emphasis is on the individual teacher. Another phase in the professional life of Mathematics teachers is the possible movement in and out of teaching. Shuard and Quadling [1980]

suggest that a spell in industry or commerce may be useful to a teacher, broadening his horizons and enabling him to see the application of his work. The process of learning is never finished for a good Mathematics teacher. No matter how well a teacher is prepared, he must continually learn; for example, by reading Mathematics journals and by attending meetings and congresses of Mathematics associations and organizations and by taking further courses to keep his knowledge up to date. Professional organizations, both national and international like MASA and ICME, are an essential part in the growth of the good Mathematics teacher. The good secondary teacher of Mathematics must be willing to share with other secondary school teachers.

A major trend in the professional life of Mathematics teachers is likely to be a growing awareness of the need for involvement in co-operative study and problem solving with their colleagues in the Mathematics department, as well as for links with the community outside the school. Professional life needs to be seen as a lifetime growth and development as well as the gradual involvement with available support services like advisers, teachers' centres, universities and colleges. There is thus a need for closer integration between pre-service education and the in-service needs of the teachers.

College teacher training should pave the way for teachers to develop throughout these phases:

"If we fail to develop Mathematics teaching into a worthwhile profession we shall continue to fail to attract into the profession a continuing supply of able mathematicians on whom the future health of school Mathematics depends, and for whom there are so many counter-attractions in industry, business and other professions."

SHUARD AND QUADLING 1980, p139.

3.2 PRE-SERVICE TRAINING OF SECONDARY SCHOOL MATHEMATICS TEACHERS

"How do we teach tomorrow's teacher to teach the Mathematics of the day after tomorrow."

The assembling of a competently trained force of Mathematics teachers is a long-term objective. The vast computer industry certainly has had the effect of reducing the number of Mathematics graduates who are attracted to teaching. Even granted sufficient recruits one must decide how a Mathematics teacher must be trained.

Approaches to teacher education vary greatly from institution to institution and from country to country, and there would seem to be as many course designs as there are trainers. As stated earlier, steps are continuously being taken to ensure that teachers entering the profession are better trained and

better educated than their predecessors. Teacher education should be regarded as a life-long process - although when we loosely refer to teacher education we usually mean initial or pre-service education. Moodley [1985] contends that teacher education programs should provide experiences that will foster continuous growth in the qualities of the teacher so that he will enhance learning by his pupil.

3.2.1 Objectives for the training of Mathematics teachers

The task of training is one of taking a student with all his existing skills and attitudes to the subject and turning him into a specialist teacher. In addition it is hoped to provide him with an appropriate start to a career in which he will take the responsibility for his own personal development and be aware of the variety of support services available to him. Thus initial training must be seen as having limited objectives in terms of practical skills, but must nevertheless introduce the student to a wide variety of aspects of his future profession and indicate to him how to adopt a truly professional approach to his work.

Prospective teachers must acquire a sound perspective on the roles of Mathematics in contemporary society and in the lives of individuals, and it is of particular importance that prospective teachers obtain not only mathematical knowledge,

but also mathematical know-how.

In this section I will look at some objectives for the training of Mathematics teachers for the secondary school. These objectives have been formulated as a result of the work of The Mathematics Teacher Education Project which was set up during 1974 in England [Wain 1980].

(a) To broaden awareness of Mathematics as a subject

The aim here is to provide prospective teachers with the opportunity to explore their own understanding of Mathematics in such a way that their knowledge will enable them to exploit fully the opportunities at school level. Possibilities for creative work within school topics exist and prospective teachers should thus be able to apply their knowledge to enliven their teaching. Quite often students do not see in elementary situations applications of more advanced work that they have already encountered as they tend to divorce it from school Mathematics.

It is therefore important for pre-service Mathematics teachers to be aware of the vast range of reference material which can provide them with background knowledge of their work. A pre-service teacher must

also be aware of the significance of what he will be teaching and have a wide view of his subject. One of the aims of the teacher training course must therefore be to try to broaden the students' approach by enlarging their idea of what is interesting mathematical activity.

One trend in methods courses for pre-service teachers has been towards developing more practical ideas and techniques such as preparing activity cards; collecting games and puzzles; making manipulative teaching aids; watching videotapes about teaching and planning lessons. O'Daffer [1984] finds that although these experiences are extremely helpful, we also have to help pre-service teachers to develop an awareness of the curriculum and a working philosophy of Mathematics instruction. To increase their awareness of content and process goals, pre-service teachers require a carefully developed set of vivid, brief and interesting experiences, because of the limited time available for method courses.

Since beginning teachers generally rely on a textbook for syllabus content and teaching sequence it would seem reasonable for teacher trainers to focus initially on textbook interpretations of the syllabus. Interesting items in Mathematics journals can also provide an awareness of curricular developments for pre-service

teachers, for example, that the current emphasis on problem solving is not new but a part of the cyclic pattern of evolution in all Mathematics curricula.

(b) **To gain an understanding of the way children think in Mathematics**

It is clear that a teacher should know something of the way his pupils' thinking determines their ability to learn Mathematics. Richard Skemp [1979] sees the problems of learning and teaching as psychological problems and says that before much improvement in the teaching of Mathematics can be made we have to know more about how Mathematics is learnt. There is a large and growing body of knowledge in the general area of the psychology of learning Mathematics that pre-service teachers should encounter. This is the area where there are obvious links with general educational studies. Pre-service teachers do not easily make the link between theory and practice so it is necessary to look at a variety of topics in the specifically subject-based part of the course.

A consideration of some particular mathematical ideas from the point of view of concept development can provide insight into the difficulties of teaching. The

analysis of the problems of language in teaching Mathematics is also an important activity for pre-service teachers. The task of the teacher is to tread carefully between the formal language of Mathematics and the natural language of the child.

Other topics that can be included under this objective include: the study of problem solving in children and adults; the nature of proof appropriate for different age abilities; the complex nature of mathematical activity and the essential difference between practice of skills and encouragement of creativity.

(c) To develop a knowledge of teaching styles and methods

With regard to this objective we are primarily concerned with the development of practical classroom procedures. Much of this work will be related to teaching practice which itself needs to be planned to provide the necessary opportunities for pre-service teachers to develop an appropriate and wide range of skills. These skills include: preparation and presentation; the use of questioning techniques in developing a topic or initiating discussions; organizing practical work and groupwork and developing an ability to make decisions quickly and effectively. Classroom teaching is a

complex business and it would seem to be necessary to isolate various techniques and develop particular skills in situations where the complexity can be reduced and the resultant improvement in teaching environment can be exploited. Approaches such as micro-teaching, group teaching, video recording, analysis of lessons and simulation techniques should be considered. In a later section more will be said about teaching practice.

(d) To explore the needs of various groups of children

New teachers are required to teach across a wide spectrum of age and ability. It is therefore necessary to think carefully not only about the needs of the gifted but also the average, less able, the remedial groups, the disillusioned, the unmotivated, the non-specialist, the early leaver, and so on. Devising work for the below-average child is generally a problem that practising teachers find hard to resolve and pre-service teachers need to be aware of the dimensions of the problem.

Differences in mental ability must be taken into account: the ability to reason or think reflectively and to solve problems must result in increasingly divergent levels of attainment if each child is encouraged to work

to the best of his ability. Some pupils may have special talents, such as a creative flair, or special deficiencies such as a lack of reading skill; and these again will have a major bearing on the type of work that is appropriate for the child to pursue. Then there will be differences of learning habits, self-discipline, attention and retention span, and organisation of written work. Naturally these differences should be taken into account in some degree by the overall school structure. In dealing with such diverse groups schools have devised a large number of organizational structures such as streaming and mixed ability groupings.

- (e) To develop knowledge of resources available to the **Mathematics teacher**

If pre-service training is seen in its proper context as only an introduction to a profession and as the first part of a career-long programme, then the introduction to resources in its widest sense is one of the most vital parts of a training course. Included here would be an introduction to journals, associations, library resources, suppliers of equipment, films, books, worksheets, etc. Teachers need access to a wide range of information and therefore knowledge of resources of that information. Gaining that knowledge is thus an

important aim of any teacher training course.

- (f) To explore the relationship between Mathematics and other subjects

For most teachers Mathematics remains an isolated subject, despite the growing interest in integrated studies. Mathematics has increasingly become an important service subject. The need for certain basic skills in Physical Science has been well known, but now other subjects such as Biology and Geography are demanding a mathematical approach in several aspects of their study. Mathematics teachers have always made use of a wide range of examples drawn from other subjects, while on the other hand, teachers of those other subjects demand that certain basic skills are taught by Mathematics teachers and quite often complain about the lack of these skills.

There is thus a real need for a closer integration at a much deeper level, where Mathematics and other subject teachers explore ways in which their subjects can converge. Intelligent pupils might survive a situation in which subjects are taught in isolation, but it is doubtful whether this approach would be acceptable for the less able. It would be desirable that pre-service

teachers see some of the potential of inter-disciplinary co-operation.

- (g) To learn essential parts of school Mathematics not previously studied

There is a need for pre-service teachers to be given the opportunity to fill in some of the gaps in their own knowledge of Mathematics. Many need an introduction to topics such as Transformation Geometry, Statistics, Applied Mathematics and Numerical Analysis. Webb [1985] in his plea that "Mathematics teachers must be mathematicians" succinctly points out that you cannot be a good teacher of anything without mastering the subject at a significantly higher level than the level at which you are going to teach, and only after you have mastered the subject should you give your attention to teaching it.

In general, as a minimum, a Mathematics teacher must know all the material that he will need to teach as well as the place of this material in the spectrum of the Mathematics curriculum. Experience confirms Egsgard's [1983] suggestion that the extent of this knowledge should be determined for each country by a committee consisting primarily of secondary school teachers,

assisted by current teacher trainers and a few tertiary mathematicians who have demonstrated an interest in secondary Mathematics education.

3.2.2 Mathematical content of pre-service training courses for secondary school teachers

Mathematics continues to grow in scope and complexity and it is applied to an increasing range of social and technological problems. As Mathematics advances there is frequently feedback to its more elementary parts, and ideas on how to sequence well-established material are sometimes modified. In consequence a teacher needs a general idea of the range of the subject, including new developments, as well as detailed familiarity with a modest area which the pre-service teacher will be able to use with competence. Furthermore the pre-service teacher needs a foundation which he can continue to expand and modify throughout his professional life.

Fletcher [1983] found that there was general consensus among many mathematicians that the two most dominant topics for a course for prospective teachers should be Calculus (Analysis) and Linear Algebra. There was also some consensus that courses should also include a strong element of Geometry, although he personally favoured a course that included a historical perspective of Geometry. There was also wide

agreement among his respondents that both a computer orientated approach to problems and Numerical Analysis should be major parts of any course, and Statistics and Probability are important studies.

But prospective Mathematics teachers require more than a good knowledge of a number of fields in Mathematics. They also require an overview of how the parts fit together and need a perspective into which they can fit fresh knowledge as they acquire it. Such an overview involves the history of the subject as well as the philosophical foundations and knowledge of where the current expanding frontiers are to be found. The history and foundations of Mathematics need to be incorporated in courses in such a way that their social relevance and their relevance to the school classroom are clearly seen. It is certain that potential users of Mathematics in business and industry require mathematical modelling as part of their studies and the intending teacher needs some familiarity with this, if only to understand better why society employs so many mathematicians.

Pre-service teachers need to gain confidence in their ability to pick up fresh Mathematics by their own efforts. Fletcher [1983] found that there is a tendency for many prospective teachers to gain no more than a precarious grasp of ideas which are presented at a level as sophisticated as the

lecturers can make it. The abstraction and generality in courses could be reduced and it would be preferable for pre-service teachers to attempt rather less, but acquire greater confidence in the work they cover. The intending teacher needs the opportunity to learn at his own level by methods which he could later adopt in his teaching. Whatever mathematical content is involved, the student should meet the ideas in forms which respect his previous knowledge and his methods of thinking.

A common complaint among young teachers is that their course preparation was too much concerned with developing mathematical knowledge and too little with showing them worthwhile methods of teaching. In teaching Mathematics to pre-service teachers it should be remembered that Teaching Method (Subject Didactics) is not a separate subject, as Fletcher aptly states:

"...good Mathematics and good methods can be studied simultaneously to the benefit of both."

FLETCHER in ZWENG 1983, p113

3.2.3 The role of Methodology in the pre-service training of secondary school Mathematics teachers

In the past decade much thought has been given to teaching "better" Mathematics in schools, but this has not always

resulted in teaching Mathematics "better". No matter what content is included in the curriculum, when presented in an unimaginative rote way, it will become meaningless and most likely implant in the pupils a dread of Mathematics.

Any curriculum for pre-service Mathematics teachers should not only spell out mathematical content, but should also indicate possible methodology that will convey the "spirit of the curriculum" [Nero 1981]. Prospective teachers should be made aware of alternative methods of presenting various topics as there is no best method for a topic.

The history of pre-service training shows that it has always been a problem to find the right balance between theory and practice in these courses. There are generally three basic types of courses: firstly courses where educational theory predominates over method courses, secondly balanced courses where educational theory and method courses are still treated separately and thirdly courses where educational theory and method are interwoven. There must of course be an interaction between methodology and general education studies. Rising [1983] suggests that it would be helpful if trainees were to interpret, "make sense of", and occasionally even contradict the ideas they meet in their educational psychology and sociology courses.

At ICME5 (1984) in Adelaide, the BACOMET (Basic Components of Mathematics in Education of Teachers) group suggested the following principles for pre-service training courses [Laridon in Olivier 1985]:

- (a) The approach must be "fundamental" in that it should be based on theory.
- (b) The courses need to be "elementary" in the sense that they must be accessible to prospective teachers. Courses should thus prepare the trainee for the practical issues to be faced and must be stimulating.
- (c) The methodology needs to be "exemplary". The prospective teacher needs to experience how theory is to be related to practice.

Courses for prospective Mathematics teachers should strive to equip them with those skills, understanding, thinking strategies and appreciations of Mathematics that will enable them to practice their profession effectively. The method course must thus be seen as the "central integrating factor" [Moodley 1985]. Information about the nature of methods courses can be obtained by analyzing the contents of textbooks used for such courses.

The Methods section of training courses should aim at the practical considerations of "putting across" sections of the

school syllabus to pupils and must also prepare the trainee with the skills for adapting to curricular changes. Moodley [1985] also contends that a method course should be developed around four important questions relating to the interacting components of the curriculum, namely:

- . aims and objectives (Why?)
- . content (What?)
- . method (How?)
- . evaluation (Whether?)

The methods course should include opportunities for real (with actual school pupils) or pseudo (with peers) micro-teaching lessons which are discussed in detail and if possible retaught in different settings. Teaching practice sessions at schools for long periods should be preceded by as much clinical practice, such as tutoring and teaching small groups, as possible.

3.2.4 School experience and teaching practice

The teaching experiences contained in the pre-service training of teachers provide a capstone to the study of mathematical content and methods, because the objectives of

both areas unite to form an effective and competent Mathematics teacher. Dossey [1983] suggests that the experiences in the clinical dimension of the pre-service teachers' programme should include opportunities for whole-class instruction; small group work; teaching of concepts, facts, techniques and skills; and working with pupils of varying ability levels.

These clinical experiences must be carefully integrated with the various topics in the methods section of the pre-service programme. They should be sequenced from structured observations to full class instruction. At the same time these clinical experiences must be allowed to grow in both duration and level of responsibility.

Initial experiences might involve the observation of selected students during concept learning or problem solving situations. These activities can provide the basis for discussion of related teaching sections and methods of meeting individual needs. They could also assist in describing effective methods of classroom organization and management.

The observation phase might be followed by assisting the classroom teacher in the final stages of the lesson. This assistance might involve working with small groups of

children as they complete an exercise. As the trainee gains experience, lesson planning should gradually shift from instructor to trainee. As the trainee grows in confidence, the transition of this responsibility becomes necessary and appropriate.

Rising [1983] found that when a classroom teacher is asked to describe his pre-service training, he is most likely to discredit all but the teaching practice. This view is supported by Howson [1983] who states that the part of the pre-service training that USA students value most is their period of practice teaching in schools. This would certainly also be the response of many newly qualified teachers in the RSA. Learning about teaching and about whether or not one should become a Mathematics teacher becomes real in the classroom. I believe that one learns to teach by doing, not by listening.

Teaching practice is an aspect of teacher training which research findings in the USA has pinpointed as one of the major areas requiring attention in any training course. Not only are the short periods of teaching practice, two or three weeks, with a few criticism lessons evaluated by lecturers, being proved inadequate, but also is the fact underlined that proper and meaningful discussion afterwards does not occur when the visiting lecturer has to fulfil a criticism lesson

appointment a short while later at another venue.

The practice of sending students to observe lessons is considered a waste of time by Americans doing research in this field, because these students do not know what to look for and seldom appreciate the significance of an experienced teacher's actions. New techniques using video tapes and the introduction of micro-teaching have proved to add significantly to the value of teaching practice as a preparation for teaching. The HSRC of the RSA (1976) recommended that special attention be given by all teacher training institutions to new developments in teaching practice techniques such as micro-teaching and video tapes to make teaching practice more dynamic and meaningful.

As an alternative to classroom practice for pre-service teachers Rising [1983] proposes an apprenticeship type of training for beginning teachers. These teachers would then be assigned to successful secondary school teachers who are currently teaching at school. As in other apprenticeship programmes these trainees should be paid a nominal salary. His view is that under this alternative, there would be no need for pre-service courses in the philosophy or psychology of education since the important ideas obtained from these courses would arise in the practical sphere during the year that the trainee spent with the co-operating teacher. He

envisaged a programme where the trainee and "expert" teacher would be responsible for the same classgroups and ample time would be set aside daily for preparation and discussion. One of the reasons why he thinks that apprenticeship is an essential part of teacher preparation is that it gives teacher trainees an opportunity to share in the joy of teaching.

This problem of bridging the gap between theory and practice is by no means found only at institutions and universities in the RSA. This is a problem that has troubled educationists all over the world for decades and many schools of thought have evolved, each offering a solution to the problem.

3.2.5 The place of micro-computers in the pre-service training of secondary school Mathematics teachers

A great amount of research is currently being done on the use of the micro-computer in the Mathematics classroom. The impact of the calculator and micro-computer is such that school curricula are certainly going to be affected in the near future. Hence the importance for pre-service courses to take timeous cognisance of the potential impact of calculators and computers in the Mathematics curriculum.

Fraser [1983] sees that teacher education faces two major

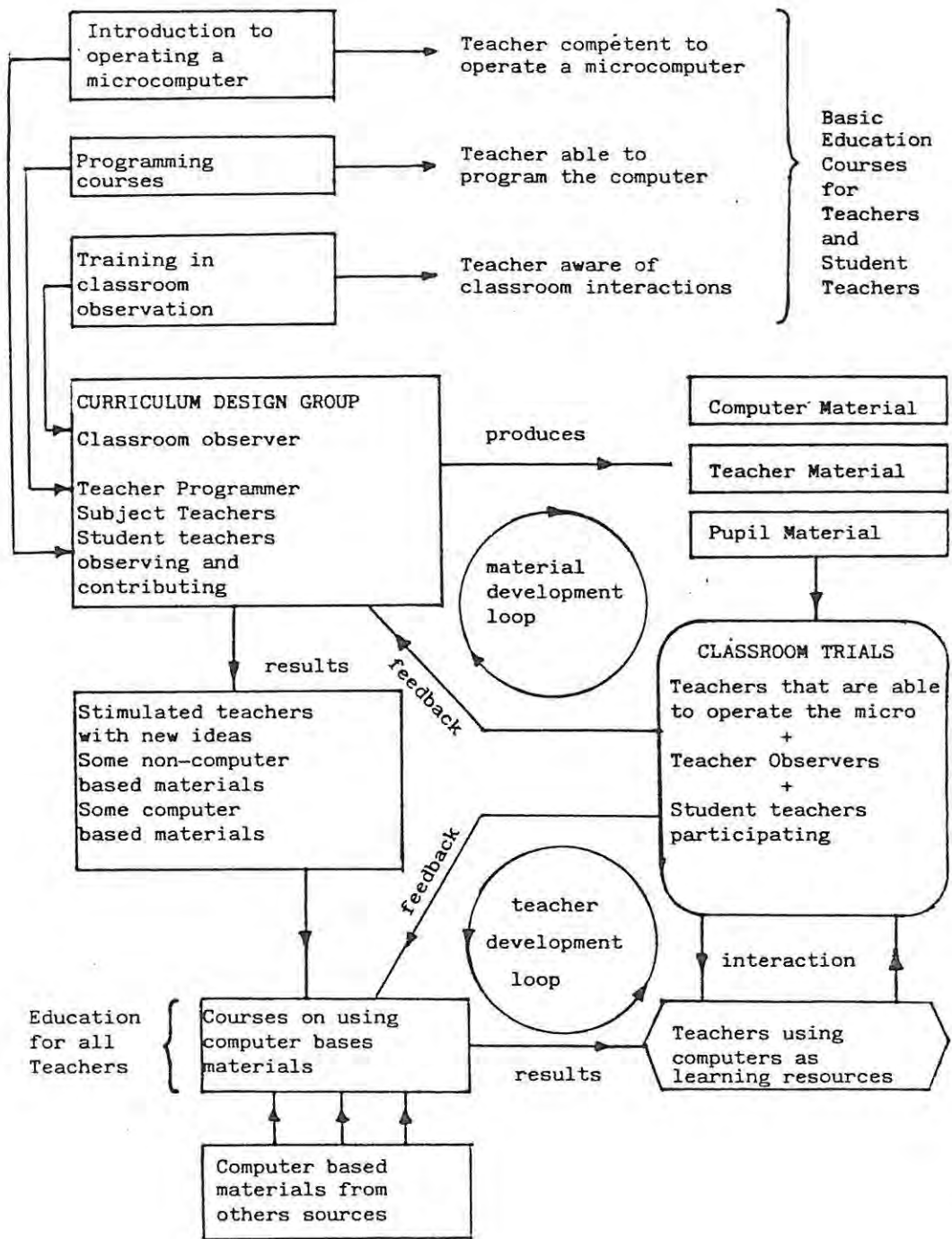
tasks in this sphere. The first is to help teachers gain confidence in their ability to handle the technology and the second is to help them adapt to the changes in the curriculum which the availability of cheap calculating and computer power will promote. Unlike passing fads in education, electronic calculating devices are sure to have a lasting influence. Considering the rapid growth of technology, the potential for electronics staggers the imagination. Calculators and computers have permeated society, including the fields of education and Mathematics.

Graf [1981] is of the opinion that for appropriate and successful computer use in the future the inclusion of computer studies as a subject in the curriculum of pre-service Mathematics teachers will be crucial. In view of these trends computers cannot be ignored in pre-service programmes for Mathematics teachers.

Two reasons for pre-service Mathematics teachers requiring instruction in computer science were given by Tony Ralston during a session on computers in Mathematics Education at ICME5 (1984) as:

- (i) In the foreseeable future demands will be made on Mathematics teachers to give instruction in Computing and Computer Science in secondary schools.

FIG.3: A MULTIDIMENSIONAL MODEL FOR TEACHER EDUCATION



- (ii) The impact that Computer Science is having on Mathematics.

A multidimensional model for Teacher Education was suggested by Rosemary Fraser [1983] in her paper delivered at ICME4 as shown in Fig.3. The model is such that it should be possible for each teacher or trainee teacher to find a participating role that suits him. The required involvement may only be the introductory course in operating a micro-computer, followed by the course in using prepared computer-based materials. The model must be well supported by course and computer materials. The centre of the model shows curricular development and teacher training as parallel activities with two possible development loops.

3.2.6 Mathematics teacher educators

One of the difficulties of the present system of teacher training in colleges of education throughout the world is that there are teacher educators who have lost touch with what is going on in the classroom. There are people expounding ideas on how to teach who have never tried these ideas in a school class.

"It is not what teacher educators do not know about teaching that hurts their trainees, but what they do know for sure that turns out to be wrong."

CONFUCIUS.

In other words the closer teacher educators are to their classroom teaching experience, the more they will be able to assist teachers. Since the pedagogic example set by trainers can be expected to have a lasting influence on the teaching styles and perspectives on Mathematics of pre-service teachers, it is to be ensured that this influence is a beneficial one. In the Draft Policy Document on Mathematical Education in S.A. compiled by MASA (1981) it was proposed that teacher trainers, in addition to being excellent teachers of Mathematics, should possess all or some of the following qualities:

- (a) The ability to assess existing curricula, curriculum materials, teaching and evaluation practices critically and constructively.
- (b) Thorough knowledge and proficiencies regarding strategies and techniques of teacher training, teacher counselling and guidance, curriculum development and dissemination of curricula.
- (c) Thorough acquaintance with the existing body of knowledge in the field of Mathematics Education.

- (d) Some acquaintance with Mathematics syllabi, teaching practices and training programmes in other countries.

The qualities mentioned above may be fostered through full-time and in-service training offered by universities and other institutions.

At college level Mathematics teacher educators engage in many professional activities, including instructing pre-service and in-service teachers, conducting research and addressing various other problems. Mathematics Education is directed toward the implementation of mathematically and educationally appropriate programmes for students and the provision of high quality Mathematics instruction. Peggy Coulter [1979] believes that everyone involved with teacher education programmes should have some responsibility for their effectiveness.

Peggy Coulter [1979] in her research study suggested that Mathematics teacher educators should be accountable for producing programmes which value students' needs, adhere to goals, and take into account current research findings. Furthermore she also suggested that teacher educators should promote and engage in research in order to strengthen the teacher training programme.

Trafton's [1984] suggestion is imperative: Mathematics teacher educators need to have close, ongoing relationships with schools and with the day-by-day teaching of Mathematics, if their efforts are to result in improved programmes and instruction.

Mathematics teacher educators thus have a major stake in school Mathematics. It is in the many thousands of classrooms where their protégés carry out Mathematics education that change must be implemented if progress in Mathematics teaching is to occur. Mathematics educators need to understand better the problems and constraints of the classroom. They need to be willing to work closely with schools on real-world problems and wrestle with ways of implementing change. Although working with schools places additional demands on the Mathematics educator, the satisfaction and learning that result from such work make it a valuable and productive experience.

To be able to deal with the real world Bender [in Olivier 1985] suggests that teacher trainers should have spent some time working outside the educational system and should get to know many examples of Applied Mathematics and Mathematics relevant to those who will never become mathematicians or Mathematics teachers themselves.

In order to facilitate bridging the gap between theory and practice, it is essential to ensure that trainers of teachers who are responsible for the Subject Didactics (Method) course have the necessary qualifications. This will ensure that trainers who are Mathematics specialists will not utilize time set aside for Method for further instruction in Mathematics content.

The danger of trainers having no insight into the didactical implications involved in the teaching of Mathematics is that their students will teach as they themselves were taught at school. It is also true that without a sound mathematical background teacher trainers will be unable to inspire prospective Mathematics teachers in the subject. For these reasons the HSRC of the RSA in its report on "The Training of Mathematics teachers in The Republic of South Africa and some Western Countries" recommends that :

"Lecturers responsible for the Method of Mathematics should have a Bachelors' Degree in Education and an Honours degree in Mathematics as a minimum academic qualification."

VAN DER BERG 1976, p280

3.3 IN-SERVICE AND SUPPORT PROGRAMMES FOR MATHEMATICS TEACHERS

It is generally realised that it is not sufficient to ensure that teachers enter schools well trained and well educated at the beginning of their working lives. Steps must also be taken to ensure that they remain so as conditions change. Thus there is an evident need for continuing in-service education.

Patricia Ashton [1983] in her book, Teacher Education in the Classroom: Initial and In-service, wrote the following about in-service training:

"In-service courses were first offered in the U.K. and elsewhere, to compensate for the inadequacy of initial training. Later on the purpose of INSET began to change and the range of courses designed widened to update, refresh and improve the competence of already trained teachers."

ASHTON et al 1983, p13.

Most educators would agree that the neophyte teacher is not a finished product at the end of a three or four year course of professional training, but is only at the readiness stage to begin teaching. The gap between the ideal situation as studied during pre-service training and the real situation in schools has still to be bridged. In a study by the University of California on Continuing Education for Teachers

it was found that in-service training is probably more important than pre-service preparation, because in the pre-service programme the prospective teacher learns about teaching whilst in the classroom the beginning teacher learns how to teach [Dunkley in Zweng 1983]. Teacher education is increasingly seen as a continuum of which pre-service and in-service programmes form integral parts. There is value in Dunkley's view that educational systems have a responsibility to provide support and assistance to enable beginning teachers to develop towards their maximum potential as quickly as possible.

These support programmes should be directed towards the needs and concerns of the beginning teacher. Although teachers welcome the kind of support which clear guidelines bring to the teaching of Mathematics one cannot assume that the guidelines will be implemented as recommended. Guidelines need also to foster confidence among teachers.

3.3.1 Support programmes for beginning teachers

There is considerable variation in the type and extent of the problems of beginning teachers. Since they have different backgrounds and enter different kinds of schools, it is not surprising to find that these difficulties show a divergence.

If the beginning teacher is to complete his adjustment to teaching he will need an opportunity to relate the theory he has mastered to the practice in which he is now involved and to do this in a supportive environment.

The specific content of induction programmes should reflect the major concerns of beginning teachers. We should also not lose sight of the fact that many new entrants to the teaching profession are of first rate calibre, well-motivated towards their work and capable of reaching a high level of performance in their first year. In developing an induction programme, it is easy to overlook or forget their particular problems and needs and to devote attention to the average or unsuccessful beginning teacher. Only by careful planning can we develop induction programmes which identify and satisfy all these varied individual needs and only then will the initial year become meaningful and relevant to every new teacher.

3.3.2 School-based support programmes

The essence of school-based in-service support is that it accomplishes the development of individual members of staff whilst they are improving the work of the school [Love 1981]. Even for very experienced staff, this will be a major

contribution to their development as teachers. Every staff has both the conditions for developing in-service work and the context in which to do it. The context is that of improving the mathematical education provided by the school. The case for some form of school-based support is strongest when such work is concerned to explore and develop the group dynamics of the classroom with particular reference to the learning of Mathematics. This can only happen when people are prepared to share classes during the working day and then meet to reflect on what has happened. The staff work in teams rather than as individuals. While some teachers may have the capacity to "go it alone", all ideas benefit from scrutiny and criticism by others. The easing of an individual teacher's work-load that co-operative working allows, enables further development to be more readily considered. Meetings are a necessary part of the procedure, but can be seen by staff as part of their lesson preparation.

Stephens [1983] sees the co-ordination of Mathematics teaching as an indispensable condition of any school-based support for teachers. Whether it is done through a designated position of head of department or through some alternative structure, it is the role which is critically important.

In co-ordinating the teaching of Mathematics within a school,

one of the key functions is that of maintaining links between teachers and those support services external to the school. This will include maintaining school memberships of regional and national associations of teachers of Mathematics.

School-based support has the advantage for the less confident teacher of being on "home ground" so that he may feel more comfortable and less threatened. The disadvantage can be in the restriction of ideas or expectations which results when participants share the same working background.

3.3.3 Mathematics advisory teachers

Advisory teachers most commonly work alongside teachers in the classroom. They spend a period of several days in the same school or visit each group of schools on a regular basis. They may perhaps help with drawing up or revising a scheme of work or assist with in-service courses arranged by the education authorities. They can play a valuable role in providing in-service support in a school and in assisting with the introduction of new approaches to teaching. Faux [1985] points out that an advisory teacher may be able to make a valuable contribution in rural areas where the distance between schools and problems of transport can make it difficult for teachers to take part in the activities of teachers' centres or to meet teachers in other schools.

3.3.4 Tertiary institutions and research

There are many examples of contributions that can be made by individuals who teach in colleges or universities. Establishments of higher education have for many years made a major contribution to the in-service support of teachers. In addition to providing full-time and part-time courses for serving teachers, their staffs engage in many other kinds of in-service support.

The university has a unique role to play because of its independence, but its contribution must be exploited in collaboration with that of others such as advisers and teachers' centres. An in-service activity run by advisers carries with it the implication of putting across an official point of view. A course run by an independent body is quite clearly a take-it-or-leave-it situation and an approach to teachers as professionals demands that they should make the final choice. Advisers and teachers' centres have a very important role to play in follow-up work and support in schools.

Increasingly, staff of training institutions assist with school based in-service work, especially in schools in which they have become known as a result of their visits to supervise students on teaching practice.

3.3.5 Professional associations

Professional associations operating at regional and national levels provide important services to teachers. Conferences have tended in recent years to steer away from the "speaker-and-those-spoken-to" model and have encouraged greater participation through workshops and material developed. Local branches of professional associations can also give teachers opportunities to discuss particular school programmes and to observe them in operation.

Journals and newsletters and a wide variety of informal publications have applied a more practical approach: communicating to teachers information about successful programmes and teaching approaches. Johnson and Rising [1972] see professional activity in Mathematics and Mathematics Education to be intimately related to two aspects of developing quality teaching: broadening background and improving classroom instruction.

Unfortunately most teachers seem to look upon participation in professional organizations as a rather arduous duty, however, many teachers have derived tremendous enjoyment and satisfaction from these activities. Often the answers to teaching problems are found in professional journals or at professional meetings.

CHAPTER FOUR

RESEARCH DESIGN

4.1 AIMS

As stated in the Introduction and Overview preceding Chapter One, the general aims of this investigation can be summarized as follows:

- (a) To determine the nature and effectiveness of the pre-service training of secondary school Mathematics teachers provided at colleges of education administered by the House of Representatives.
- (b) To determine the attitude of Mathematics teacher educators at colleges of education towards the pre-service training of secondary school Mathematics teachers.
- (c) To determine the attitude of beginning secondary school Mathematics teachers towards their pre-service training.
- (d) To evaluate the current Mathematics syllabi offered for the pre-service training of secondary school Mathematics teachers at colleges of education and to present possible proposals for a revision.

4.2 THE SAMPLE

In order to investigate the pre-service training of secondary school Mathematics teachers at colleges of education under the control of the House of Representatives, questionnaires were sent to:

- (a) All heads of Mathematics departments at colleges of education administered by the House of Representatives.
- (b) All Mathematics teacher educators at the above colleges of education.
- (c) Beginning secondary school Mathematics teachers with less than 4 years teaching experience.

4.2.1 The sample of heads of departments

There are presently 12 colleges of education under the control of the House of Representatives, but questionnaires were sent to only 11 of these institutions, because one of the colleges of education only trains teachers for the pre-primary level. The 11 colleges are situated in 3 provinces of the Republic of South Africa: one in Transvaal, one in Natal and nine in the Cape. Although presently only 5 of these colleges offer the HDE (Secondary) course, data from all the colleges were gathered because the possibility exists

for the HDE (Secondary) course to be offered in future at any of the colleges (refer to 1.3.2). Teachers trained at the other 6 colleges are in any case presently teaching in secondary schools, even though they have not been trained for secondary school teaching.

Questionnaires were sent to all the heads of Mathematics departments at the 11 colleges of education and all the heads of departments responded to the questionnaire. The information gathered from the heads of departments thus fully represents the total population.

4.2.2 The sample of Mathematics teacher educators

Information regarding the number of Mathematics teacher educators at the 11 colleges of education was obtained from the heads of Mathematics departments. During 1986 there were 42 lecturers at the 11 colleges of education responsible for teaching Mathematics. Questionnaires were sent to all 42 Mathematics lecturers and 39 (92,9%) lecturers responded to the questionnaire.

The sample of Mathematics lecturers used for this investigation can thus be considered as representative of the total population of Mathematics lecturers at the 11 colleges

of education. The information gathered from the sample of Mathematics lecturers can thus be considered to be representative of the total population of Mathematics teacher educators at the 11 colleges of education.

4.2.3 The sample of beginning secondary school Mathematics teachers

Data was also obtained from secondary school Mathematics teachers with less than 4 years teaching experience. The reason for limiting the experience to less than 4 years was that teachers with more than 3 years experience would not have followed the current courses offered at colleges of education (refer Chapter 1).

Official statistics regarding the total number of secondary school Mathematics teachers during 1986 with less than 4 years teaching experience were not available at the time of the survey. I decided to use convenience sampling by sending questionnaires to secondary school Mathematics teachers in Natal and the Eastern Cape. Details of beginning Mathematics teachers in the above regions were obtained from data that I had as subject adviser for these regions. During 1986 a total of 54 Mathematics teachers at secondary schools in the above regions had less than 4 years teaching experience and

questionnaires were sent to all of them.

A total of 43 (79,6%) teachers responded to this questionnaire. Three of the respondents (7,0%) had no professional training, while 7 of the respondents (16,3%) had not completed their professional training. Rather than scrap these responses it was decided to take note of them, but prevent them from influencing any relevant statistics.

The following are some of the main characteristics of the sample of teachers:

SEX

<u>Male</u>	<u>Female</u>	<u>TOTAL</u>
33	10	43
76,7%	23,3%	

LANGUAGE

<u>English</u>	<u>Afrikaans</u>	<u>TOTAL</u>
20	23	43
46,5%	53,5%	

MEAN AGE

<u>Male</u>	<u>Female</u>	<u>TOTAL</u>
24,1	22,9	23,8

TEACHING EXPERIENCE (in years)

<u>None</u>	<u>One</u>	<u>Two</u>	<u>Three</u>	<u>TOTAL</u>
15	6	9	13	43
34,9%	14,0%	20,9%	30,2%	

MATRIC MATHEMATICS SYMBOLS OF TEACHERS

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>TOTAL</u>
2	3	7	15	9	4	*40
5,0%	7,5%	17,5%	37,5%	22,5%	10,0%	

* Three repondents had not offered the subject in matric.

During 1986 there were 212 secondary schools administered by the House of Representatives and the sample of teachers was obtained from 49 secondary schools and thus represented 23,1% of the total population of secondary schools. Data obtained from the heads of departments at the colleges of education (see Table 1 on p.102) showed that 20 HDE (Secondary) Mathematics teachers qualified in 1985 and the sample of beginning teachers included 6 (30,0%) of these teachers. The sample of teachers were trained at 7 of the 11 colleges of education and thus represented 63,6% of the colleges of education.

Official statistics at the time of this investigation, regarding the number of Mathematics teachers at secondary

schools with less than 4 years teaching experience were not available. It was thus not possible to determine exactly how representative of the total population the sample was.

4.3 THE QUESTIONNAIRES

Three different questionnaires were compiled for the different populations as set out in 4.2.

QUESTIONNAIRE A:

This questionnaire (see Appendix A) was sent to heads of Mathematics departments at colleges of education. It consists of questions on: statistical details of Mathematics students, personal details of lecturers, resources for teaching Mathematics and support services for Mathematics teachers. It is by means of this section that I wish to determine the nature of the pre-service training of Mathematics teachers at colleges of education and to determine the effectiveness of such training.

QUESTIONNAIRE B:

This questionnaire (see Appendix B) was sent to Mathematics lecturers at all colleges of education and consists of 2 parts. The first part consists of questions on personal details of the lecturers and the other part consists of

questions based upon the interest and attitudes of lecturers towards Mathematics, Mathematics Education and computers in education. A number of open-ended questions are also included in the second part of this questionnaire.

One of the omissions of this questionnaire is that question 3.2 should have asked whether lecturers actually read journals on the teaching of Mathematics instead of simply asking whether they subscribe to such journals. The responses and comments of lecturers to question 8 of this questionnaire indicated that this question was not clearly phrased and some of the lecturers took offence at the inclusion of this question (as explained in 4.5). Another omission is that the nature of appointment (permanent or temporary) of the lecturers was not considered.

It is by means of this section that I wish to determine the interests and attitudes of Mathematics lecturers towards the pre-service and in-service training of Mathematics teachers.

QUESTIONNAIRE C:

This questionnaire (see Appendix C) was sent to secondary school Mathematics teachers in their first 3 years of teaching and consists of 2 parts. The first part requires some personal details of the teachers and the other part consists of five questions relating to the interests and

attitudes of the teachers towards their initial training and to micro-computers in the teaching of Mathematics.

It is by means of this section that I wish to determine the views of beginning Mathematics teachers on their pre-service training at colleges of education.

4.4 ADMINISTRATION OF THE QUESTIONNAIRES

The questionnaires were sent during the second term of 1986 to individual heads of Mathematics departments at colleges, and to Mathematics lecturers at these colleges and beginning secondary school Mathematics teachers. The questionnaires were completed by each of these individuals and were returned during the second and third terms of 1986.

4.5 SCORING OF THE QUESTIONNAIRES

The frequencies of responses to the following items in the three questionnaires were recorded (refer Tables 1 to 17 in Chapter 5):

- (a) Questionnaire A: Questions 4 and 5.

- (b) Questionnaire B: Questions 1; 2; 3.2; 3.3; 3.4; 4; 5;
6.2; 7.1;; 7.2; 7.3; 7.5; 7.6.
- (c) Questionnaire C: Questions 1.2; 1.4; 1.5; 1.6; 1.7;
2; 3; 5.1; 5.1; 5.3; 5.4; 5.5; 5.6.

The responses of lecturers to question 8 of Questionnaire B showed that most of the respondents (58,9%) did not answer this question. This question required the respondents to relate 8 topics taken from the HDE (Secondary) didactics syllabus to aspects of the process of teaching Mathematics. A number of respondents indicated that they did not understand the question and 33,3% were of the opinion that the question aimed to test their knowledge and objected to its inclusion. The responses of a number of lecturers who answered this question were also incomplete and would affect the results. In the light of this I decided to ignore this question in this investigation and the responses were not recorded.

The responses to the following open-ended questions in the three questionnaires were recorded:

- (a) Questionnaire A: Questions 4.1; 4.2; 4.6; 5.1(b);
5.2; 5.3; 5.4; 5.5; 5.6.
- (b) Questionnaire B: Questions 1.4; 2.1; 3.1; 4.5; 4.6;
5.5; 5.6; 6.1; 6.3; 6.4; 6.5; 7.4.
- (c) Questionnaire C: Questions 1.2; 1.3; 1.5; 2.1; 5.7.

CHAPTER FIVE
RESULTS OF THE SURVEY

5.1 NUMBER OF STUDENT-TEACHERS TAKING MATHEMATICS AT
 COLLEGES OF EDUCATION FROM 1982 TO 1986

This study is based on the existing pre-service training of secondary school Mathematics teachers at colleges of education administered by the House of Representatives. The present teacher training courses offered at the 11 colleges of education were only introduced in 1982 and previous courses were phased out at the end of 1983, therefore only data pertaining to existing courses was obtained.

Table 1 gives an analysis of the number of students at the 11 colleges of education taking Mathematics as a subject from 1982 to 1986. The data pertaining to the HDE (Secondary) course was obtained from 5 colleges of education where the course was offered.

Although this investigation is aimed at the pre-service training of secondary school Mathematics teachers, data pertaining to all Mathematics students was obtained, because students achieving an aggregate of at least 65% at the end of

TABLE 1: NUMBER OF STUDENTS TAKING MATHEMATICS FOR THE VARIOUS COURSES FROM 1982 TO 1986

Courses offered at Colleges of Education	Number of students offering Mathematics as a subject during				
	1982	1983	1984	1985	1986
(a) Higher Diploma in Education (Secondary) N %				20 0,53	24 0,64
(b) Higher Diploma in Education (Senior Primary) N %				21 0,56	3 0,08
(c) Diploma in Education III (Secondary) N %			20 0,7	36 0,9	37 0,99
(d) Diploma in Education III (Senior Primary) N %			210 7,7	279 7,4	380 10,2
(e) Diploma in Education II (Secondary) N %		27 1,6	47 1,7	66 1,8	57 1,5
(f) Diploma in Education II (Senior Primary) N %		509 30,7	794 29,1	1146 30,4	1244 33,29
(g) Diploma in Education I (Secondary) N %	142 18,2	201 21,8	250 9,2	309 8,2	315 8,4
(h) Diploma in Education I (Senior Primary) N %	634 81,8	922 55,9	1405 51,6	1890 50,2	1676 44,9
TOTALS	776	1659	2726	3767	3736

the first year of the DE (Senior Primary) course are allowed to change to the HDE (Secondary) course. Also HDE (Secondary) students can, during their first 3 years of study, change to either the DE (Senior Primary) or DE (Practical) courses, by applying to the Department of Education for the necessary permission.

Of the original 142 HDE (Secondary) students who took Mathematics in their first year of study (1982), only 27 continued with the subject in their second year (1983) and eventually only 20 (14,08%) of the original 142 students continued with the subject in the fourth year of study (1985). A similar pattern is also found from the data for the second intake of students (1983) for the HDE (Secondary) course, when 201 students took the subject in the first year of study and only 24 (11,94%) of these students eventually ended up taking Mathematics in the fourth year of study (1986).

With the introduction of the new courses of study (1982) only 142 (18,2%) of the first year students took Mathematics at the advanced level as prescribed for the HDE (Secondary) course, while 634 (81,8%) of the first year students took the subject at the elementary level as prescribed for the DE (Senior Primary) course. In the final year of study (1985) only 20 (0,53%) out of a total of 3767 Mathematics

students took the subject for the HDE (Secondary) course, while 21 (0,56%) took the subject at elementary level for the HDE (Senior Primary) course.

A similar pattern emerged for the second (1983) intake of students, when only 201 (21,8%) of the first year students took the subject for the HDE (Secondary) course and 922 (55,9%) took the subject at elementary level for the DE (Senior Primary) course. In the final year (1986) only 24 (0,64%) out of a total of 3736 Mathematics students took the subject for the HDE (Secondary) course, while only 3 (0,08%) students took the subject for the fourth year of the HDE (Senior Primary) course.

The data as shown in Table 1 indicates very high drop out rates of 85,92% and 88,06% respectively for the first 2 intakes (1982 and 1983) for the HDE (Secondary) course. The data in Table 1 also show that for the third (1984) intake of students for the HDE (Secondary) course a similar pattern of high drop out rates developed. One of the factors that has an effect on the drop out rate is that a student could have passed Mathematics in the first year, but possibly did not fulfill other requirements to continue with the HDE (Secondary) course (refer to 1.3.4). It must also be remembered that Mathematics is a compulsory subject only for the first 2 years of study, but optional for subsequent years.

The available data as shown in Table 1 indicates that only small percentages of student-teachers at the 5 colleges of education opted for the HDE (Secondary) course. The growth in the number of Mathematics students (1982 to 1986) is low relative to the growth of the total number of Mathematics students at the colleges of education over the same period. The negative growth rate (-13,6%) for the second year of study during 1986 is possibly partly due to the lecture and examination boycotts at all the colleges of education during 1985.

5.2 QUALIFICATIONS OF MATHEMATICS TEACHER EDUCATORS AT COLLEGES OF EDUCATION

Table 2 shows the data obtained from the heads of the Mathematics departments at the 11 colleges of education, as well as the responses of individual lecturers with respect to the academic and professional qualifications of Mathematics teacher educators during 1986. Table 2 shows that during 1986 there were 42 Mathematics teacher educators at the 11 colleges of education and that 39 (92,9%) of these teacher educators responded to the questionnaire (see Appendix B).

TABLE 2: ACADEMIC AND PROFESSIONAL QUALIFICATIONS OF MATHEMATICS TEACHER EDUCATORS AT COLLEGES OF EDUCATION DURING 1986

		Number of Mathematics lecturers at colleges of education during 1986				
		*N=39	%	**N=42	%	
ACADEMIC	NON GRADUATES		7	18,0	7	16,7
	B. Sc.	Mathematics III	14	35,9	15	35,6
		Mathematics II	2	5,1	2	4,8
		Mathematics I	14	35,9	16	38,1
	B.Sc. (Hons) (Mathematics)		2	5,1	2	4,8
	Other Degrees	B.A.	6	7,6	6	14,3
		B.A. (Hons.)	1	2,5	1	2,4
		B. Sc. (Hons.)	1	2,5	1	2,4
		M. Sc.	2	5,1	2	4,8
		B.P. Ed.	1	2,5	1	2,4
		B. Com.	1	2,5	1	2,4
PROFESSIONAL	PTD III		2	5,1	4	9,5
	HDE/STD/UED		17	43,6	18	42,8
	B. Ed.		12	30,8	12	28,6
	NONE		8	20,5	8	19,1

*N : Number of individual lecturers that responded to the questionnaire

**N: Total number of Mathematics lecturers at colleges of education

5.2.1 Academic qualifications

Table 2 shows that in 1986 there were 7 (16,7%) Mathematics lecturers at the colleges of education with no university courses in Mathematics, 4 (9,5%) of these lecturers offered the subject for the PTD course and the other 3 (7,2%) only offered the subject at matric level. An honours degree in Mathematics had been attained by only 2 (4,8%) of the lecturers, while 15 (35,6%) of the lecturers had taken the subject as a major for their degree and 16 (38,1%) of the lecturers only had one degree course in Mathematics.

Table 2 shows that there were 35 (83,3%) lecturers with science degrees, 7 (16,7%) with arts degrees and one (2,4%) lecturer had a commerce degree. A Bachelor in Primary Education degree was offered by one (2,4%) of the lecturers. A Master of Science degree in some other subject had been attained by 2 (4,8%) lecturers.

The responses of the sample of Mathematics lecturers indicated that 27 (69,2%) graduate lecturers offered mathematically related subjects for their academic qualifications. The 6 subjects indicated by the 27 lecturers were Physics (15), Applied Mathematics (13), Chemistry (9), Statistics (8), Computer Science (7) and Biology (1). The subject offered by most (55,5%) of the graduates was Physics,

while only 1 (3,7%) lecturer took Biology.

Considering the criteria (see 1.2 and 3.2.6) for the minimum academic qualifications for secondary school Mathematics teachers, only 19 (45,2%) of the Mathematics lecturers at the 11 colleges of education during 1986 were qualified to teach at secondary school level. If an honours degree in Mathematics is considered as minimum academic qualification for teacher trainers, then only 2 (4,8%) lecturers at the 11 colleges of education were academically qualified for their positions as college lecturers.

5.2.2 Professional qualifications

Table 2 shows that in 1986 there were 8 (19,1%) Mathematics lecturers at the 11 colleges of education with no professional qualification. The Bachelor of Education degree had been attained by 12 (28,6%) of the lecturers, while 18 (42,8%) lecturers had a post-graduate teachers' diploma and 4 (9,5%) lecturers had a three-year teachers' diploma (PTD) obtained at a college of education. Three types of post-graduate teachers' diplomas, namely, HDE, STD and UED, were indicated by the respondents. One of the lecturers had followed a four-year degree in primary education (see 5.2.1).

If the recommendations of the HSRC of the RSA (1976) with regard to minimum professional qualifications for teacher trainers are taken as the yardstick then only 12 (28,6%) lecturers during 1986 were professionally qualified for the positions they were holding. And if the recommendations of the HSRC with respect to both minimum academic and professional qualifications are applied, then none of the lecturers during 1986 were qualified for their positions as Mathematics lecturers at colleges of education (see 3.2.6).

5.2.3 Qualifications of Mathematics teacher educators instructing HDE (Secondary) students during 1986

Table 3 shows the qualifications of Mathematics lecturers who during 1986 instructed the HDE (Secondary) students at the 5 colleges of education where the course was offered.

During 1986 the HDE 1 (Secondary) Mathematics students at the 5 colleges of education were instructed by 5 professionally trained lecturers. One of these lecturers had no university courses in Mathematics, 3 lecturers had one course in the subject and one lecturer had majored in the subject.

During 1986 the HDE 2 (Secondary) students were instructed by 6 lecturers of whom 2 had no professional qualifications. One of the lecturers had no university course in Mathematics,

3 lecturers had one course in the subject, while 2 lecturers had majored in the subject.

The HDE 3 and HDE 4 (Secondary) students were instructed during 1986 by 5 professionally qualified lecturers of whom 2 had honours degrees in Mathematics, 2 had majored in the subject and the other lecturer only had 2 university courses in the subject.

TABLE 3: QUALIFICATIONS OF MATHEMATICS TEACHER EDUCATORS INSTRUCTING HDE (SECONDARY) STUDENTS DURING 1986

YEAR OF STUDY	NUMBER OF LECTURERS					HONOURS	TOTAL
	UNIVERSITY COURSE IN MATHEMATICS						
	0	1	2	3			
HDE 1	1	3		1			5
HDE 2	1	3		2			6
HDE 3			1	2	2		5
HDE 4			1	2	2		5

5.3 **TEACHING EXPERIENCE OF MATHEMATICS TEACHER EDUCATORS AT COLLEGES OF EDUCATION**

Table 4 gives the primary, secondary and tertiary teaching experience of all the Mathematics teacher educators up to 1986. The experience of the heads of departments and other Mathematics lecturers has been recorded separately. Information regarding the nature (permanent or temporary) of appointment of the lecturers is not included in this study, because of a shortcoming in the questionnaire.

5.3.1 **Teaching experience of heads of Mathematics departments**

Table 4 shows that the tertiary experience of heads of Mathematics departments at the 11 colleges of education ranged from 0 to 16 years, while the secondary school experience of the lecturers ranged from 4 to 18 years. The data as shown in Table 4 also indicates that most (64,3%) of the heads of departments had less than 6 years secondary school experience and the mean teaching experience of the heads of departments was 7,4 years. Also most (60,6%) of the heads of departments had less than 6 years tertiary experience, their mean teaching experience being 6,3 years.

All the heads of departments at the 11 colleges of education

TABLE 4: TEACHING EXPERIENCE OF MATHEMATICS TEACHER EDUCATORS AT COLLEGES OF EDUCATION

TEACHING EXPERIENCE IN YEARS		NUMBER OF MATHEMATICS LECTURERS							
		N	%	*N	%	**N	%	***N	%
Primary School	None	11	100	22	71,0	33	78,6	30	76,9
	1 - 5			8	25,8	8	19,0	8	20,5
	6 - 10			1	3,2	1	2,4	1	2,6
Secondary School	None			10	32,3	10	23,8	10	25,6
	1 - 5	5	64,3	14	45,1	19	45,2	18	46,1
	6 - 10	2	11,9	6	19,4	8	19,0	7	17,9
	11 - 15	2	11,9	1	3,2	3	7,1	2	5,2
	more than 15	2	11,9			2	4,9	2	5,2
Tertiary (College)	None	1	9,1	7	22,6	8	19,0	7	17,9
	1 - 5	6	60,8	15	48,4	22	52,4	20	51,3
	6 - 10	1	9,1	5	16,1	6	14,3	6	15,4
	11 - 15	2	11,9	4	12,9	6	14,3	5	12,8
	more than 15	1	9,1			1	2,4	1	2,6
Totals		11		31		42		39	

N : Number of heads of departments

*N : Number of lecturers excluding the head of department

**N : Total number of lecturers

***N: Number of lecturers that responded to questionnaire B

had some secondary school teaching experience, but none of them had primary school experience, while only one (9,1%) of them had no previous experience at tertiary level. The responses to the questionnaires also indicated that none of the heads of departments had experience other than teaching.

These statistics as shown in Table 4 indicate that the heads of departments at the 11 colleges of education are mostly inexperienced.

5.3.2 Teaching experience of other Mathematics teacher educators

The data (*N) as shown in Table 4 indicates that most (77,4%) of the 31 Mathematics lecturers had less than 6 years secondary school teaching experience and that most (71,0%) of them had less than 6 years tertiary experience. The mean teaching experience at primary, secondary and tertiary levels of these lecturers was respectively 4, 4,6 and 5,7 years.

The tertiary experience of the 31 lecturers ranged from 0 to 34 years, while their secondary school teaching experience ranged from 0 to 19 years and their primary school teaching experience ranged from 0 to 5 years. Table 4 also shows that 7 (22,6%) lecturers at the 11 colleges of education had no previous tertiary experience, while 10 (32,3%) had no

secondary school teaching experience and only 9 (29,0%) lecturers had primary school teaching experience.

The responses indicate that 5 (12,0%) Mathematics lecturers had other experience apart from teaching. These non-teaching experiences included jobs in fields such as Metallurgy, Analytical Chemistry, Chemistry, laboratory work and research in Physiology.

The data as reflected in Table 4 indicates that in 1986 most of the lecturers at the 11 colleges of education had limited teaching experience at the 3 teaching levels. In response to question 5.3, inquiring whether teacher educators should have school experience (see Appendix B), 35 (89,2%) lecturers indicated that it is necessary for teacher educators to have school teaching experience.

5.4 INTEREST AND PROFESSIONAL PREPAREDNESS OF MATHEMATICS TEACHER EDUCATORS

5.4.1 Further studies of Mathematics teacher educators

During 1986 five (11,9%) lecturers at different colleges of education were involved with further studies in the field of Mathematics Education. One of these lecturers, as a part-time student, took Curriculum Studies in Mathematics as

a subject for the B.Ed. degree. One of the heads of department worked on a dissertation during 1986 on Mathematics Education as part fulfilment for a post-graduate degree at a British university, after having spent one year in the U.K. as a British Council scholarship student. A third lecturer was doing research for the completion of a Ph.D. on Computer Assisted Instruction through an American university. The other 2 respondents did not indicate their field of study. All the respondents agreed on the usefulness of research on the teaching of Mathematics.

Ten other lecturers at the colleges of education were following additional part-time courses in Mathematics and Statistics. Six of these lecturers were doing Mathematics I, 3 Mathematics II and one lecturer was doing Mathematics III. This shows that 6 of the 7 lecturers (see 5.2.1) who had no university courses in Mathematics were attempting to acquire such background.

5.4.2 Affiliation to professional associations

Four colleges of education (see Table 6) indicated that they were affiliated to the Mathematics Association of South Africa (MASA). Table 5 shows that only 10 (25,6%) Mathematics lecturers indicated that they were affiliated to

TABLE 5: RESPONSES OF TEACHER EDUCATORS TO QUESTIONS (2.1 - 2.9) ON SUPPORT SERVICES FOR MATHEMATICS TEACHING

Questions		Response		YES	NO	TOTAL
		N	%			
2.1	Affiliation to a Mathematical Association	N	%	10 25,6	29 74,4	39
2.2	Attendance of National Conventions	N	%	8 20,5	31 79,5	39
2.3	Attendance of MASA conferences	N	%	9 23,1	30 76,9	39
2.4	What does ICME stand for?	N	%	3 7,7	36 92,3	39
2.5	Attendance of ICME congresses	N	%	0 0	39 100%	39
2.6	Familiar with guidance material of Subject Advisors	N	%	11 28,2	28 71,8	39
2.7	Attendance of short courses of Subject Advisors	N	%	13 33,3	26 66,7	39
2.8	Conference on training of Mathematics teachers	N	%	39 100,0	0 0	39
2.9	Assistance to pupils for Mathematics Olympiads	N	%	15 38,4	24 61,6	39

TABLE 6: RESPONSES OF HEADS OF DEPARTMENTS TO QUESTIONS (5.1 - 5.6) ON SUPPORT SERVICES

Questions		Response		YES	NO	TOTALS
		N	%			
5.1 (a)	Refresher courses on current syllabi offered	N	%	0	11 100,0	11
5.1 (b)	Lecturers consult with lecturers from other Colleges	N	%	6 54,5	5 45,5	11
5.2	Subject meetings held by Head of the Mathematics Department	N	%	11 100,0	0 0	11
5.3	In-service-training of Mathematics teachers	N	%	5 45,5	6 54,5	11
5.4	Assistance to secondary or primary school pupils	N	%	3 27,3	8 72,7	11
5.5	Lecturers meet with Mathematics Subject Advisors	N	%	2 18,2	9 81,8	11
5.6	Affiliation to mathematical Associations	N	%	4 36,4	7 63,6	11

a mathematical association. The responses of the Mathematics teachers indicates that none of them were affiliated to any mathematical association (see Table 16). Congresses of MASA had been attended by only 9 (23,1%) lecturers and only 2 lecturers from the 11 colleges of education had attended the congress held at the University of Stellenbosch (1986). This is a disappointing picture seeing that 6 of the colleges are situated in the Western Cape. Also 8 (20,5%) lecturers had attended the National Conventions of Science and Mathematics Teachers arranged by the Foundation for Science, Education and Technology and only one lecturer from one of the colleges was present at a recent convention held at Rhodes University (1987).

5.4.3 International Congress on Mathematical Education

Table 5 shows that only 3 (7,7%) lecturers at the 11 colleges of education responded correctly to question 2.4, requiring the meaning of ICME (see Appendix B), and that none of the lecturers had attended any of these congresses. It is alarming that 92,3% of the Mathematics teacher educators at the colleges of education appear to be ignorant about ICME. The 3 respondents referred to above erroneously interpreted ICME as a council or committee. Also the responses of the

sample of lecturers indicated that only 51,3% of the lecturers used the journal Spectrum, in which notices and reports on ICME congresses have been published (see Table 8).

ICME congresses are held each leap year and are attended by leading mathematical educationists who discuss recent research and new developments in Mathematics Education (also see 2.2.1). Trainers of Mathematics teachers should acquaint themselves with reports delivered at these congresses and should at least be aware of the existence of such congresses.

5.4.4 Involvement with support services

In 1982 the Department of Education introduced an advisory service for Mathematics teachers. Only 2 (18,2%) heads of departments (see Table 6) indicated that they had informal contact with Mathematics subject advisers during panel inspections. Only 11 (28,2%) lecturers indicated that they were familiar with the guidance material issued by the subject advisers. Short courses and seminars are held annually for secondary school Mathematics teachers and only 13 (13,3%) college lecturers indicated that they had voluntarily attended such short courses previously. Some of the lecturers had recently been teaching at secondary schools and had had direct contact with the advisers. All the

respondents to the questionnaire (Appendix B) indicated that they would prefer to have greater contact with subject advisers and agreed that a conference for Mathematics lecturers on the training of Mathematics teachers should be arranged by the department.

Five of the colleges of education are offering part-time courses for practising teachers to upgrade their qualifications. Three colleges of education run programs during school vacations for matric pupils in preparation for their final examinations. Fifteen (38,4%) lecturers indicated that they had previously given assistance to pupils in preparation for Mathematics olympiads.

5.5 TEACHING FACILITIES AND RESOURCES FOR MATHEMATICS AT COLLEGES OF EDUCATION

Table 7 gives the responses of heads of departments at the 11 colleges of education to questions 4.1 to 4.10 (see Appendix A) relating to resources for teaching Mathematics.

5.5.1 Teaching facilities

Table 7 shows that 4 (36,4%) heads of departments indicated that Mathematics lecturers at their institutions had their own subject rooms and 4 colleges had a venue used as a laboratory for teaching Mathematics. Classroom facilities at

TABLE 7: RESPONSES OF HEADS OF DEPARTMENTS TO QUESTIONS (4.1 - 4.10) ON RESOURCES FOR TEACHING MATHEMATICS

Questions		Response		TOTAL	
		YES	NO		
4.1	Prescribed textbook used for Content Section	N %	9 81,8	2 18,2	11
4.2	Prescribed textbook used for Method Section	N %	4 57,1	7 42,9	11
4.3	Study material on Method Section issued to students	N %	11 100,0	0 0	11
4.4	Classroom/laboratory for teaching Mathematics available	N %	4 57,1	7 42,9	11
4.5	Mathematics lecturers have own subject rooms	N %	4 57,1	7 42,9	11
4.6	College subscribes to journals on Mathematics Education	N %	10 90,9	1 9,1	11
4.7	Textbooks on the teaching of Mathematics available in college libraries	N %	9 81,8	2 18,2	11
4.8	Funds available for acquiring teaching aids for Mathematics	N %	6 54,5	5 45,5	11
4.9	Teaching aids for mathematics supplied by the Education Department	N %	11 100,0	0 100,0	11
4.10	Students required to construct teaching aids for practice teaching	N %	11 100,0	0 100,0	11

all the colleges of education are generally limited, resulting in lecturers having to share venues and at 4 colleges specific venues are set aside for use by the Mathematics lecturers. The equipped classrooms (laboratories) for teaching Mathematics were found during personal visits to all the colleges of education in 1986, to be teaching venues used mostly by Mathematics lecturers and where wallcharts and some teaching aids were stored and displayed.

5.5.2 Teaching aids

Table 7 shows that all the heads of departments indicated that teaching aids are supplied by the Department of Education. During inspection visits to the colleges in 1986 I found that the teaching aids referred to consisted of writingboard instruments, overhead projectors, audio and video apparatus as well as microcomputers. Six (54,5%) colleges make funds available to the Mathematics departments for the purchase of teaching aids and most of these funds are used for acquiring transparency films and overhead-pens.

All the colleges indicated that student-teachers are required to construct teaching aids for use during practice teaching, but the responses (refer to Table 9) of the sample of

TABLE 8: RESPONSES OF TEACHER EDUCATORS TO QUESTIONS (3.2 - 3.4) ON LIBRARY RESOURCES FOR TEACHING MATHEMATICS

Questions		Response		YES	NO	TOTALS
		N	%			
3.2	Subscribe to journals on the teaching of Mathematics	N	%	9 23,1	30 76,9	39
3.3a	Spectrum	N	%	20 51,3	19 48,7	39
3.3b	The Mathematics Teacher	N	%	17 43,6	22 56,4	39
3.3c	Mathematics Teaching	N	%	9 23,1	30 76,9	39
3.3d	Mathematical Digest	N	%	11 28,2	28 71,8	39
3.3e	Pythagoras	N	%	6 15,4	33 84,6	39
3.3f	Imstus News	N	%	4 10,3	35 89,7	39
3.3g	Journal of the Natal Teachers' Mathematics Association	N	%	0 0	39 100	39
3.4	Recommended list of suitable reference material	N	%	38 97,4	1 2,6	39

TABLE 9: RESPONSES OF TEACHERS TO QUESTIONS (5.1 - 5.6)
RELATING TO THEIR PRE-SERVICE TRAINING

Response		Yes	No	Other*	Total
5.1	Made teaching aids for Mathematics	N 30 69,7	9 21,0	4 9,3	43
5.2	Lecturer used teaching aids.	N 31 72,1	8 18,6	4 9,3	43
5.3	Applied methods used by lecturers.	N 26 60,5	13 30,2	4 9,3	43
5.4	Schemes of work were discussed.	N 18 41,9	21 48,8	4 9,3	43
5.5	Mathematics syllabi for schools were discussed.	N 14 32,6	25 58,1	4 9,3	43
5.6	Attention given to the teaching of Mathematics to special students.	N 16 37,2	23 53,5	4 9,3	43

* No response (no pre-service training)

secondary school teachers to a similar question (see Appendix C) show that only 30 (69,7%) teachers stated that during their pre-service training they constructed teaching aids for teaching Mathematics. The responses of secondary school teachers (Table 9) show that only 31 (72,1%) teachers agreed that teaching aids were used by Mathematics lecturers during their pre-service training.

5.5.3 Library resources

It is alarming to find (see Table 7) that 2 (18,2%) heads of departments indicated that reference material on the teaching of Mathematics was not available while, on the other hand, 58,1% of the sample of teachers indicated that reference material was not available in the college library (see Table 11). This was investigated and it was found that reference books on teaching Mathematics are in fact available, but are mostly limited to school textbooks. Lists of reference books available in college libraries were submitted with the return of the questionnaire (refer to Appendix E for the list of books available in the libraries at colleges of education).

Only one college did not subscribe to journals on Mathematics Education. Nine (23,1%) lecturers indicated that they personally subscribed to journals on the teaching of

Mathematics (see Table 8).

The Department of Education provides funds for colleges of education to subscribe to journals such as Spectrum, Archimedes, Mathematics Teacher and Arithmetic Teacher, and this could be the reason why 76,9% of the respondents indicated that they personally do not subscribe to such journals. One of the inadequacies of the questionnaire sent to lecturers is that it should rather have determined whether lecturers read these journals.

With reference to Table 8 the journal Spectrum is used by 51,3% of the sample of Mathematics lecturers. The second most popular journal used by lecturers is The Mathematics Teacher (43,6%). The journal of the Natal Teachers' Mathematics Association is not used by any of the lecturers and the use of other local publications by the lecturers ranges between 10,3% and 28,2%. The newsletter of MASA, Pythagoras, which is issued to members, is used by only 15,4% of the lecturers. Responses to the question inquiring whether lecturers are affiliated to a mathematical association revealed that only 25,6% of the lecturers are affiliated to MASA.

The low percentage of lecturers (see Table 8) who are using journals on the teaching of Mathematics is a matter of grave

concern, as it can be an indication that prospective Mathematics teachers at colleges of education are not fully exposed to the value of journals for their professional growth, as reflected in Table 16 showing that only 4 (9,4%) of the sample of Mathematics teachers subscribe to local journals on the teaching of Mathematics.

5.5.4 References for teaching Subject Didactics

Twenty six (66,7%) lecturers responded to question 3.1, inquiring whether they used reference material for Subject Didactics (see Appendix B), and indicated the reference works used by them. Of these 26 lecturers 5 commented that they refer to a number of reference works for the teaching of Subject Didactics.

A list of 10 reference books being used in 1986 is shown below:

<u>Title and Author</u>	<u>Number of lecturers</u>
1. <u>Mathematics in secondary schools.</u> P.G. Scopes.	2
2. <u>Teaching kids Mathematics.</u> C. Barnett.	2
3. <u>Method of Mathematics.</u> V.E. Schnugh, A.P. Fortuin.	8
4. <u>Teaching and Learning Mathematics for Secondary schools.</u> F.H. Bell.	3

- | | | |
|-----|---|---|
| 5. | <u>Teaching secondary Mathematics.</u> Butler, Wren and Banks. | 2 |
| 6. | <u>Dynamics of Teaching Secondary school Mathematics.</u> | 1 |
| 7. | <u>Learning Mathematics: A cognitive science approach.</u> | 1 |
| 8. | <u>Wiskunde vir onderwys studente vir die senior primere fase.</u> Van Rensburg et al | 1 |
| 9. | <u>Teaching Mathematics.</u> University of Cape Town study guide. | 1 |
| 10. | <u>Mathematics Subject Didactics.</u> Unisa study guide. | 3 |

The most popular textbook used by the lecturers is by V.E. Schnugh and A.P. Fortuin titled: Method of Mathematics. Eight of the respondents (30,8%) indicated the use of the aforementioned book as main reference for teaching Subject Didactics. This 48 page book is completely inadequate as it is designed for use by primary school teachers and deals mostly with the administrative aspects of teaching Mathematics and is thus not suitable for the training of secondary school Mathematics teachers. This is also the same book that 4 heads of departments indicated as being prescribed for the students (see Table 7).

Most of the lecturers (97,4%) in their responses indicated that a recommended list of suitable reference material on Subject Didactics would be of great assistance. Also 29 (74,4%) lecturers indicated that a textbook, if available, based on all the topics prescribed for Subject Didactics would be of great assistance.

5.6 SUBJECT DIDACTICS

5.6.1 Method of Mathematics as a prerequisite for Mathematics teacher educators

From a total of 39 respondents to the questionnaire sent to Mathematics lecturers at colleges of education, 20 (51,3%) lecturers had followed a course in Method of Mathematics for their initial training as Mathematics teachers. It has been found that 48,7% of the Mathematics lecturers who were engaged in the training of Mathematics teachers in 1986 had themselves not followed a university course in Method of teaching Mathematics. This high percentage of lecturers who do not have a university course in Method of Mathematics is a matter of grave concern since all Mathematics teacher educators at the colleges of education investigated are responsible for the teaching of Subject Didactics.

Seven of the 19 lecturers who did not have any course in Method of Mathematics also had no professional qualifications, while 4 of the 19 lecturers had nothing more than the Method of Mathematics course obtained in their initial training at a college of education.

The questionnaire (see Appendix B) also revealed that 17 (43,6%) lecturers frequently referred to the original study material to which they were introduced during their own

course of study in Method of Mathematics. Moreover 4 (10,3%) lecturers indicated that in conducting their classes they used these study guides on Method of Mathematics as their main reference for teaching Subject Didactics to their students. It was also found that all the lecturers at the colleges issued study material (lecture notes) to their students.

5.6.2 Views of Mathematics teacher educators on the Subject Didactics course presented at colleges of education

Thirty four (87,2%) of the sample of lecturers indicated that specific lecturing time is set aside by them for the teaching of Subject Didactics to their students (see Table 12). This indicates that there are teacher educators who are either integrating the content and method sections of the subject, or teaching these 2 sections in isolation.

Twenty two (56,4%) lecturers (see Table 10) indicated that they were satisfied with the topics as prescribed for the Subject Didactics section of the syllabus. Only 2 (5,1%) of the respondents indicated that there were topics that they felt should be excluded from the Subject Didactics sections of the syllabus. Also, only 9 (23,1%) lecturers named some topics that they were teaching that were not specifically

TABLE 10: RESPONSES OF TEACHER EDUCATORS TO QUESTIONS (7.1 - 7.6) ON SUBJECT DIDACTICS FOR MATHEMATICS

Questions		Response			TOTAL
		YES	NO	NO RESPONSE	
7.1	Use of study material	N 17	15	7	39
		% 43,6	38,5	17,9	
7.2	Use of electronic calculators	N 4	33	2	39
		% 10,3	84,6	5,1	
7.3	Satisfied with Subject Didactics topics	N 22	10	7	39
		% 56,4	25,6	18,0	
7.5	Topics to be excluded	N 2	16	21	39
		% 5,1	41,0	53,9	
7.6	Use of textbook as main reference.	N 29	6	4	39
		% 74,4	15,4	10,2	

prescribed for Subject Didactics. The topics named by these lecturers are (numbers in brackets indicate the number of lecturers who named these topics):

Psychology of Mathematics	(3)
Self-discovery learning	(4)
Problem solving techniques	(4)
Brainstorm approach	(2)
New school syllabi	(1)

5.6.3 Views of Mathematics teachers on the Subject Didactics course followed at colleges of education

Tables 9 and 11 show the responses of the sample of secondary school Mathematics teachers to questions 3.1 to 3.9 (see Appendix C) based on their initial training at colleges of education. Four of the respondents had not been trained at colleges of education and they did not respond to these questions.

Most of the respondents (76,7%) valued the Subject Didactics taught to them at college and found the course to be interesting, but a lower percentage (60,5%) indicated that they applied the teaching methods of their lecturers (see Tables 9 and 11). Also 27 (62,8%) indicated that not enough Subject Didactics was taught and 30 (69,7%) agreed that more lecturing time should be allocated to Subject Didactics.

TABLE 11: RESPONSES OF TEACHERS TO QUESTIONS (3.1 - 3.9) RELATING TO THEIR PRE-SERVICE TRAINING

Questions		Response			
		Yes	No	Other *	
3.1	Mathematical content sufficient for teaching.	N	29	10	4
		%	67,4	23,3	9,3
3.2	Value of Subject Didactics.	N	33	6	4
		%	76,7	14,0	9,3
3.3	Enough Subject Didactics taught at College.	N	12	27	4
		%	27,9	62,8	9,3
3.4	More time to be allocated to Subject Didactics.	N	30	9	4
		%	69,7	21,0	9,3
3.5	Subject Didactics course was interesting.	N	33	6	4
		%	76,7	14,0	9,3
3.6	Inspired further study in the teaching of Mathematics.	N	23	16	4
		%	53,5	37,2	9,3
3.7	Used prescribed book for Subject Didactics.	N	6	33	4
		%	14,0	76,7	9,3
3.8	Received study material from lecturers.	N	30	9	4
		%	69,7	21,0	9,3
3.9	Reference material available in College Library.	N	25	14	4
		%	58,1	32,6	9,3

* No response (no pre-service training).

A low percentage (53,5%) of the Mathematics teachers indicated that the Subject Didactics course followed by them inspired further study in the teaching of Mathematics. The latter result could be due to the fact that they have only recently started teaching and were still adapting to the teaching situation.

Only 6 (14,0%) teachers indicated that they used a prescribed textbook for Subject Didactics and most of the respondents (69,7%) indicated that they received study material (lecture notes) on the teaching of Mathematics from their Mathematics lecturers.

Only 18 (41,9%) Mathematics teachers indicated that current school Mathematics syllabi were discussed during their pre-service training (see Table 9). These low percentages could be due to the fact that only 43,5% of the respondents followed a training course for secondary school Mathematics teachers. Also 41,9% of the respondents indicated that schemes of work for secondary school Mathematics were dealt with during their initial training. Sixteen (37,2%) respondents indicated that attention was given to the teaching of Mathematics to special students.

Only 2 (4,7%) teachers who were trained at colleges of education did not give their impressions of the Subject

Didactics course that they had followed. Eight different impressions were stated by the respondents and are listed below, with the number of respondents for each impression given in brackets:

- * Insufficient time spent on Subject Didactics and too much emphasis on Content (16)
- * Interesting and helpful (13)
- * Inadequate (4)
- * Not sufficient teaching approaches (3)
- * Too much emphasis on the use of the overhead projector (3)
- * Requirements and role of subject advisers lacking (3)
- * Enjoyed teaching practice (3)
- * Not stimulating (boring) (2)

Although 13 respondents found the Subject Didactics course they had followed to be interesting and helpful, the general impression was that insufficient attention is given to Subject Didactics.

5.7 MATHEMATICS CONTENT

All the Mathematics lecturers agreed that prospective secondary school Mathematics teachers require knowledge of the subject beyond matric level. Twenty nine (67,4%) of the

TABLE 12: RESPONSES OF TEACHER EDUCATORS TO QUESTIONS
(5.1 - 5.6) ON THE PRE-SERVICE TRAINING
OF MATHEMATICS TEACHERS

Questions		Response			TOTALS	
		YES	NO	NO RESPONSE		
5.1	Lecturing time set aside for Subject Didactics	N %	34 87,2	5 12,8		39
5.2	Usefulness of research on the teaching of Mathematics	N %	39 100,0	0 0		39
5.3	Necessity for teacher train- ers to have school experience	N %	35 89,2	4 10,8		39
5.4	Necessity for knowledge of Mathematics beyond matric	N %	39 100,0	0 0		39
5.6	Inclusion of additional topics on Mathematics	N %	11 28,2	19 48,7	9 23,1	39

Mathematics teachers (see Table 11) found the mathematical content taught to them during their initial training to be sufficient. The negative responses of the other teachers could be because some of them did not follow the course for secondary teachers.

Table 12 shows that only 11 (28,2%) Mathematics lecturers indicated that the content as prescribed is insufficient and that additional topics should be included for the pre-service training of secondary school Mathematics teachers, while 4 lecturers did not respond to this question (see Appendix B). Topics not related to mathematical content were also given by the respondents and the following relevant topics were suggested by the lecturers:

- Transformation Geometry
- Discrete Mathematics
- Boolean Algebra
- Numerical Analysis
- More on Series
- More on Polar Coordinates

Most of the colleges (81,8%) prescribe textbooks for mathematical content. The prescribed books referred to consist mostly of secondary school textbooks and only the following 4 relevant books were listed:

- * Calculus with Analytical Geometry. M. Potters and C. Morrey.
- * Engineering Mathematics. K. Stroud.
- * Analytic Geometry and Calculus. A.W. Goodman.
- * Calculus. Shaum's series by F. Ayres.

5.7.1 Need for change

In response to a question (see Appendix B) on the necessity for the revision of school Mathematics syllabi only 7 lecturers did not respond and the responses were grouped in 5 categories as follows, with the frequencies indicated in brackets:

- * To keep pace with technological advances. (17)
- * Developments in Mathematics Education. (9)
- * New developments in Mathematics. (9)
- * Changing needs of society. (4)
- * Requirements for further study. (4)

5.7.2 Euclidean Geometry

In response to the question (see Appendix B) on the reasons for the inclusion of Euclidean Geometry in existing school

syllabi, 12 lecturers did not respond and the following are the main reasons given by the respondents (frequencies indicated in brackets):

- * Developing logical reasoning in children. (11)
- * Application of the axiomatic, deductive system. (7)
- * To relate with the real world. (7)
- * To teach problem solving techniques. (2)
- * To teach drawing skills. (2)
- * To promote analytical thinking in pupils. (1)

Some of the aforementioned responses of the lecturers indicate that there are Mathematics lecturers who are not familiar with the value of Euclidean Geometry as a topic for school Mathematics.

Also 22 (56,4%) Mathematics lecturers still regard an axiom as a self-evident truth, while 7 (18,0%) lecturers did not respond to the question (see Appendix B). I find it alarming that such a high percentage of Mathematics lecturers still have this "classical" conception of an axiom in contrast to the modern belief. This is possibly due to the lack of knowledge of the respondents regarding Non-Euclidean Geometries and is further exemplified by the list of topics, suggested by 13 lecturers, that could be used for teaching the axiomatic-deductive structure of Mathematics at school

level. Most of the lecturers (66,7%) did not respond to this question and the following topics were suggested, with frequencies indicated in brackets:

* Topology	(4)
* Group Theory	(3)
* Trigonometry	(3)
* Transformation Geometry	(1)
* Projective Geometry	(1)
* Analytic Geometry	(1)
* Set Theory	(1)
* Number Theory	(1)

The topics Topology, Group Theory, Set Theory and Number Theory are suitable for inclusion in school Mathematics syllabi, but the practical implications of the other suggested topics for teaching the axiomatic-deductive structure of Mathematics at school level are questionable.

5.7.3 Functions

The lecturers were required to write down a suitable definition of a function based on the 1984 secondary school syllabus. Sixteen lecturers did not respond to this question (see Appendix B) and the responses given were grouped by me

as follows, with frequencies given in brackets:

* Sets of ordered pairs	(9)
* Special Relations	(8)
* Mappings	(3)
* Interdependence of variables	(3)
* Machines	(1)

It is disappointing that most of the respondents were not familiar with the greater emphasis on functions in the new syllabi and that only a few (3) were aware of the functional interdependence between variables.

5.8 MICRO-COMPUTERS

Questions on the use and role of micro-computers in the teaching of Mathematics were included in the questionnaires for both the lecturers and teachers (see Appendices B & C). Tables 13 and 14 show the responses of the sample of college lecturers and Mathematics teachers to questions relating to the role of micro-computers in the teaching of Mathematics.

Presently computer literacy courses are offered at the 11 colleges of education using the Commodore 64 system and all secondary schools of the Department have been supplied with such systems. The TOAM computer system has also been

TABLE 13: RESPONSES OF TEACHER EDUCATORS TO QUESTIONS (4.1 - 4.7) ON MICRO-COMPUTERS IN THE TEACHING OF MATHEMATICS

Questions		Response		YES	NO	TOTAL
		N	%			
4.1	Usefulness of computers for the teaching of Mathematics	N	%	39	0	39
				100,0	0	
4.2	Necessity for Mathematics teachers to have some knowledge of micro-computers	N	%	39	0	39
				100,0	0	
4.3	Using computers for the teaching of Mathematics	N	%	6	33	39
				15,4	84,6	
4.4	Assist students during computer sessions	N	%	11	28	39
				28,2	71,8	
4.5	Knowledge of operation of a micro-computer	N	%	23	16	39
				58,9	41,1	
4.6	Knowledge of programming	N	%	26	13	39
				66,7	37,3	
4.7	Interest in a course on role and use of computers	N	%	37	2	39
				94,8	5,2	

TABLE 14: RESPONSES OF TEACHERS TO QUESTIONS (2.1 - 2.6) ON MICRO-COMPUTERS IN THE TEACHING OF MATHEMATICS

Questions		Response		Yes	No	Total
		N	%			
2.1	Know how to operate a micro-computer.	N	%	19	24	43
				44,2	55,8	
2.2	Knowledge of Computer Programming.	N	%	11	32	43
				25,6	74,4	
2.3	Use computers to assist with teaching Mathematics.	N	%	0	43	43
					100,0	
2.4	Computers can be useful for teaching Mathematics.	N	%	40	3	43
				93,0	7,0	
2.5	Necessary for Mathematics teachers to have knowledge of the use of micro-computers.	N	%	40	3	43
				93,0	7,0	
2.6.1	Computer literacy course useful.	N	%	12	3	15
				80,0	20,0	*
2.6.2	Written programs for use in the Mathematics classroom.	N	%	2	13	15
				13,3	86,7	*

* : Only 15 of the 43 respondents had attended a computer literacy course.

supplied to some colleges, but due to the lack of suitable software it has not yet been utilized effectively. Fifteen Mathematics teachers had followed a computer literacy course at these colleges and 11 (28,2%) lecturers indicated that they assisted students during these courses. Only 3 (20,0%) of the sample of teachers that followed the computer literacy course did not find it useful.

All the Mathematics lecturers at the 11 colleges of education and most of the teachers (93,0%) agreed that micro-computers can be useful for the teaching of Mathematics and that it is necessary for Mathematics teachers to have some knowledge of micro-computers. Most of the lecturers (84,6%) also agreed that the use of electronic calculators will not inhibit pupils' mathematical development or reasoning (see Table 10).

Most of the Mathematics lecturers (58,9%) are familiar with the operation of micro-computers at basic level and 66,7% of them have an elementary knowledge of programming. On the other hand only 44,2% of the Mathematics teachers have followed a computer literacy course and 11 (25,6%) teachers have some knowledge of programming.

One lecturer has an M.Sc. in the Instructional use of Computers, 2 lecturers offered Computer Science III as a major for their degrees, 4 offered Computer Science I, two

have a Diploma in Datametrics, one offered computer studies as part of an M.Ed. degree, while 15 lecturers followed a computer literacy course offered by the Department of Education. The programming languages that the 26 (66,7%) lecturers have indicated are as follows: Basic, Fortran, Logo, Pascal, Pilot, Cobol and Lisp.

Only 6 (15,4%) lecturers indicated that they use micro-computers to assist with the teaching of Mathematics. Even though 2 teachers indicated that they had written programs for use in the Mathematics classroom none of the sample of teachers used computers to assist with the teaching of Mathematics (see Table 14). Most of the lecturers (94,8%) indicated that they would be interested in following a course directed at the role and use of micro-computers in the teaching of Mathematics.

These results indicate that lecturers and teachers are aware of the potential role and use of micro-computers in the teaching of Mathematics and that prospective teachers need to be introduced to computers during their initial training as Mathematics teachers. The use of the computer for teaching Mathematics has not yet taken root in the classroom and here more attention should be directed during pre-service and in-service training especially in the light of the availability of computers at colleges and secondary schools.

5.9 OTHER SCHOOL SUBJECTS FOR MATHEMATICS TEACHERS

Questions were included in the questionnaires for both the lecturers and teachers (see Appendices B & C) to determine which school subjects other than Mathematics are taken by prospective Mathematics teachers during their initial training.

TABLE 15: SCHOOL SUBJECTS OTHER THAN MATHEMATICS OFFERED BY THE SAMPLE OF MATHEMATICS TEACHERS AS MAJORS FOR THEIR PRE-SERVICE TRAINING

School Subject		Biology	Physical Science and Chemistry	Geography	History	English	Afrikaans	Accounting
Number of teachers	N	23	9	10	3	5	8	4
	%	53,4	20,9	23,3	7,0	11,6	18,6	9,3

Table 15 shows that most of the teachers (53,4%) offered Biology as a subject for their initial training and only 3 (7,0%) offered History. Twenty-two of the sample of Mathematics lecturers indicated that Physical Science should be offered as a subject for Mathematics teachers, while only 6 lecturers were of the opinion that Biology should be offered by prospective Mathematics teachers as a subject for their initial training. Other subjects suggested by the lecturers are as follows (with frequencies indicated in brackets): Geography (3), Economics (3) and Accounting (3).

All the Mathematics teachers offered at least one mathematically related subject for their initial training and most of the teachers (97,6%) indicated that they relate Mathematics to other school subjects (see Table 16).

5.10 EXPERIENCES OF BEGINNING TEACHERS

Table 16 shows that 10 (23,2%) Mathematics teachers indicated that they did not follow a teaching course with the specific intention of teaching Mathematics. The following are the other subject choices of these respondents:

TABLE 16: RESPONSES OF TEACHERS TO QUESTIONS (1.2 - 1.7)

Questions		Response		
			Yes	No
1.2	Followed teaching course with the intention of being a Mathematics teacher	N	33	10
		%	76,7	23,2
1.4	Confidence in teaching Mathematics	N	41	2
		%	95,3	4,7
1.5	Affiliation to any mathematical association	N	0	43
		%		100,0
1.6	Subscribe to local journals on the teaching of Mathematics	N	4	39
		%	9,4	90,6
1.7	Relate Mathematics to other school subjects	N	42	1
		%	97,6	2,4

- * Music
- * Biology (2)
- * Kindergarten Didactics
- * Languages
- * Geography (3)
- * Accounting
- * Art

Because of the shortage of Mathematics teachers at secondary school level, beginning teachers with some college qualifications in Mathematics are often required to teach the subject in place of their major subject. Most of the teachers (95,3%) indicated that they felt confident in teaching Mathematics at secondary school level and the reason why the other 2 teachers possibly did not feel confident is because of their lack of sufficient background in Mathematics.

Table 17 shows that most of the respondents (34,9%) were in their first year of teaching and were instructing pupils from standard 6 to 10. In 1986, 13 (30,2%) respondents had 3 years teaching experience, 9 (20,9%) teachers had 2 years and 6 (14,0%) only had one year of teaching experience.

These results show that beginning teachers are expected to teach a wide range of pupils in the different standards at

secondary schools and require sound training to cope with these demands.

TABLE 17: SECONDARY CLASS SECTIONS TAUGHT BY THE SAMPLE OF MATHEMATICS TEACHERS

Experience in years		Standards	Less than one year	1 year	2 years	3 years	Total
Six	N		6	2	3	3	14
	%						32,5
Seven	N		7	1	4	2	14
	%						32,6
Eight	N		0	2	1	5	8
	%						18,6
Nine	N		1	1	1	3	6
	%						14,0
Ten	N		1	0	0	0	1
	%						2,3
Total	N		15	6	9	13	43
	%		34,9	14,0	20,9	30,2	100,0

CHAPTER SIX

FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 FINDINGS AND RECOMMENDATIONS

In this section the main findings and recommendations of this investigation will be given. The analysis and recommendations regarding the content of the Mathematics syllabi for the four years of study for the HDE (Secondary) course are also included in this section.

6.1.1 Prospective Mathematics Teachers

The data obtained from the questionnaires shows that only a small percentage of prospective teachers at colleges of education take Mathematics for the HDE (Secondary) course. The growth in the number of prospective teachers taking Mathematics as a subject for the HDE (Secondary) course is also very low. The possible reasons for the low growth rate and small number of prospective teachers taking Mathematics for the HDE (Secondary) course could be the following:

- (a) The entrance requirements for the HDE (Secondary) course offered at colleges of education are equivalent to matriculation exemption, resulting in prospective teachers rather opting to follow courses offered at universities.
- (b) Only a small number of prospective teachers gaining entrance to colleges of education have taken Mathematics as a matric subject, resulting in only a few qualifying to offer Mathematics for the HDE (Secondary) course.
- (c) The lack of interest of prospective teachers in the teaching of Mathematics.
- (d) The lack of interest of matriculants in teaching as a profession.

The data obtained from the questionnaires also indicates very high drop-out rates of students taking Mathematics as a subject for the HDE (Secondary) course. Reasons for these high drop-out rates could be the following:

- (a) The lack of interest of students in Mathematics.
- (b) The lack of interest of students in the teaching of Mathematics.
- (c) The lack of motivation of students by Mathematics lecturers in the teaching of Mathematics.
- (d) Pass requirements for the HDE (Secondary) course could

result in students passing Mathematics in their first year of study, but not fulfilling other pass requirements.

- (e) Mathematics being a compulsory subject only for the first two years of study for the HDE (Secondary) course and optional for subsequent years.

Data obtained from the responses of the sample of Mathematics teachers show that most of them took a mathematically related subject for their initial training. Most of the sample of lecturers also agreed that prospective Mathematics teachers should take at least one mathematically related subject for their initial training. The findings of this study also show that the members of the sample of beginning teachers are required to teach Mathematics to a wide range of standards.

RECOMMENDATIONS:

- (1) According to the Education Act, No. 73 of 1969, the training of secondary school teachers should be solely the function of universities, so, in the light of the ineffectiveness of the training of Mathematics teachers at colleges of education, the Education Department should reconsider its decision to offer the HDE (Secondary) course at colleges of education.
- (2) The Department of Education should consider investigating

the effectiveness of the total curriculum for the HDE (Secondary) course, because similar situations to that pertaining in Mathematics could also exist for other subjects.

- (3) The HDE (Secondary) course for prospective Mathematics teachers should rather be offered at only one or two colleges of education, because of the small number of students following the course.
- (4) Mathematics lecturers at the colleges of education should try to motivate more students to take Mathematics as a subject for the HDE (Secondary) course.
- (5) Prospective secondary school Mathematics teachers should take at least one mathematically related subject for their initial training.

6.1.2 Qualifications of Mathematics teacher educators

The data obtained from the questionnaires shows that only 2 Mathematics lecturers at the 11 colleges of education have a post-graduate qualification in Mathematics and that there are Mathematics lecturers with no university credits in the subject teaching Mathematics to HDE (Secondary) students. This is a matter of grave concern seeing that the Mathematics content of the course is based on topics taught at first year

university level. On the other hand, the investigation also found that there were lecturers following part-time courses to upgrade their knowledge of Mathematics.

The findings of this investigation show that there are also Mathematics lecturers with no professional training and that only a small percentage of lecturers have a B.Ed. degree. The data obtained also shows that a high percentage of professionally trained Mathematics lecturers did not take Method of Mathematics for their own initial training. Only a small percentage of Mathematics lecturers at the time of this investigation were involved in further studies in Mathematics Education.

The Subject Didactics for Mathematics is an integrated part of the course and is taught by all the Mathematics lecturers, and it is a matter of concern that there are Mathematics teacher educators at colleges of education with no professional training and that there are also Mathematics teacher educators with no course in Method of Mathematics.

A significant aspect of these findings was that none of the lecturers at the colleges of education fulfilled the minimum requirements for secondary school Mathematics teacher educators, as recommended by the HSRC in their report on the training of Mathematics teachers in the RSA.

The system of secondary school Mathematics teacher training at colleges of education under the control of the House of Representatives appears to be only at Stage 2 of Dr Beeby's four-stage model for the development of educational systems in developing countries.

The appointment of Mathematics lecturers at colleges of education who are not suitably qualified for the training of Mathematics teachers is possibly due to the following:

- (a) Shortage of suitably qualified Mathematics teachers.
- (b) The lack of interest of suitably qualified Mathematics teachers applying for positions at colleges of education.
- (c) The lack of applicants for advertised posts at colleges of education.
- (d) The requirements for appointment of lecturers at colleges of education are too lenient.
- (e) Some of the colleges of education were originally training schools for non-matriculation teachers and maintained some of their existing staff when they were upgraded.
- (f) Some lecturers teaching Mathematics have originally applied for positions in other subject departments and due to staffing problems are required to teach Mathematics.

RECOMMENDATIONS :

- (1) The Department of Education should raise the minimum requirements for appointment of lecturers for positions at colleges of education.
- (2) The minimum requirements for appointment of secondary school Mathematics lecturers, as recommended by the HSRC, should be an honours degree in Mathematics as well as a B.Ed. degree.
- (3) Mathematics lecturers filling temporary positions and who are not suitably qualified could be transferred to secondary or primary schools.
- (4) Suitably qualified secondary school Mathematics teachers could be seconded to the colleges of education where needed.
- (5) In-service training courses should be offered by the Education Department for Mathematics lecturers who are not suitably qualified but holding permanent posts at the colleges of education.
- (6) A time limit should be set for Mathematics lecturers at the colleges of education who are not suitably qualified, to acquire the necessary qualifications.
- (7) The assignment of Mathematics lecturers to teach courses in Mathematics Education should be made with the consideration of their interests and knowledge of

Mathematics and Mathematics Education.

6.1.3 Teaching experience of Mathematics teacher educators

The data obtained from the questionnaires shows that all the heads of departments and most of the Mathematics lecturers at the colleges of education have less than 6 years secondary school teaching experience, while a number of lecturers have no secondary school experience. Most of the Mathematics lecturers at the colleges of education have less than 6 years experience at tertiary level, and only a few lecturers have experience other than teaching. The investigation also shows that all the lecturers agree that teacher educators for secondary school Mathematics teachers should have relevant teaching experience.

In short, these findings show that the teaching experiences of Mathematics lecturers at the colleges of education are generally limited and that some lecturers have no school experience.

RECOMMENDATIONS:

- (1) Mathematics teacher educators should be assigned duties in such a way as to take advantage of their specific

teaching experiences.

- (2) More rigorous selection standards should be imposed in the recruitment process, by requiring evidence of highly successful relevant school teaching experience so as to develop Mathematics teacher educators who are exemplars of effective teaching.
- (3) Since the pedagogic example set by trainers can be expected to have a lasting influence on the teaching styles and perspectives on Mathematics of pre-service teachers, teacher educators should have relevant classroom experience and the closer they are to such experience the more they will be able to assist teachers.
- (4) In view of (3), secondary school Mathematics teacher educators should periodically be assigned to teach at secondary schools, to be able to understand the problems and constraints of the classroom.
- (5) To be able to deal with the real world a system should be devised so that teacher trainers could spend some time outside the educational system and thus get to know many examples of applications of Mathematics relevant to school Mathematics.

6.1.4 Support services

This investigation shows that most of the Mathematics lecturers at the colleges of education are not affiliated to any professional Mathematics association. Congresses and conventions of MASA have been attended by only a handful of Mathematics lecturers and most of the Mathematics lecturers were ignorant of the ICME congresses. The apparent lack of interest of Mathematics lecturers in professional Mathematics associations, as shown in the findings of this research, is a matter of concern. Not surprisingly, data obtained from beginning teachers shows that none of these respondents were affiliated to a professional association for Mathematics teachers.

The apparent lack of interest in MASA could possibly be due to the following:

- (a) National congresses of MASA were initially racially segregated and there are lecturers still opposed to it because of this.
- (b) Some of the MASA congresses did not coincide with the school vacations for 'Coloured' schools and colleges.

The findings of this investigation confirmed that Mathematics lecturers at colleges of education have hardly any contact

with the subject advisers for secondary schools and the only association some lecturers had with the advisory service was during their period of teaching at secondary schools. The data obtained from beginning teachers as well as the responses of lecturers show that there exists a need for Mathematics lecturers and Mathematics subject advisers to work more closely together.

The data obtained from the questionnaires also shows that very few Mathematics lecturers are involved in offering assistance to secondary school pupils and teachers. However, some of the colleges of education are offering part-time courses for practising teachers to improve their qualifications.

RECOMMENDATIONS:

- (1) Colleges of education and Mathematics lecturers should be affiliated to professional Mathematics associations.
- (2) The Education Department or the colleges of education could provide financial assistance for Mathematics teacher educators to attend national and international Mathematics Education congresses.
- (3) The advisory service for secondary school Mathematics teachers could be extended to include the colleges of education. Mathematics subject advisers with college

experience could be used for this purpose.

- (4) Seminars and short-courses given by Mathematics subject advisers should also be attended by Mathematics lecturers.
- (5) Mathematics lecturers at colleges of education should be more involved with the in-service support of secondary school Mathematics teachers, especially for beginning teachers.

6.1.5 Resources for teaching Mathematics

The data obtained from the questionnaires shows that special teaching facilities (laboratories) for Mathematics at the colleges of education are non-existent, mostly because of the shortage of teaching venues at all the colleges. This situation would be partly remedied by the current and planned extensions to existing colleges of education.

Available teaching aids consist mostly of overhead projectors and micro-computers. Other concrete teaching aids for teaching specific concepts from the secondary school syllabi are mostly non-existent.

The survey also revealed the lack of suitable reference material (journals and textbooks) on Mathematics and

Mathematics Education in college libraries. It appears that available funds for reference material are not sufficiently utilized for acquiring Mathematics journals and textbooks.

The lack of suitable journals and textbooks in the college libraries could be the reason why most of the lecturers indicated that they were not familiar with certain journals on Mathematics Education. The low percentage of lecturers familiar with journals on Mathematics teaching is a matter of concern, as it could be an indication that prospective Mathematics teachers are not fully exposed to the use and value of journals for their professional growth during their initial training.

RECOMMENDATIONS:

- (1) Future planning and extensions of colleges of education should include the provision of special teaching venues (laboratories) for Mathematics.
- (2) Resource centres for Mathematics teaching should be established at colleges of education to satisfy the needs of prospective teachers as well as practising Mathematics teachers at schools close to the colleges.
- (3) Appropriate resources in sufficient quantities should be readily available for use by prospective teachers. Such resources should include: periodicals and books for study

in Mathematics and Mathematics Education; audiovisual equipment; instructional materials and micro-computers.

6.1.6 Subject Didactics

The responses of the lecturers and teachers show that insufficient attention is given to the teaching of Subject Didactics. The responses of the teachers indicate that most of them found the topics on Subject Didactics interesting and useful, but not adequate for their needs. The single period set aside weekly by most of the lecturers appears to be inadequate.

None of the colleges of education prescribe a suitable textbook on Subject Didactics for use by the HDE (Secondary) students, and references used by some of the lecturers appear to be inadequate for the training of secondary school Mathematics teachers. The lack of suitable and adequate reference material on Subject Didactics in college libraries is a matter of concern.

Most of the lecturers indicated their satisfaction with the content of the Subject Didactics course and very few suggested additional topics to be included for the training of secondary school Mathematics teachers. This apparent lack

of insight is a matter of concern.

An analysis of the content of the Subject Didactics for the HDE (Secondary) course can be summarized as follows (also see Appendix D):

(a) First Year

The contents of the Subject Didactics component as prescribed for the first year of the HDE (Secondary) course are based on the syllabi for the senior primary classes and thus not related to the secondary course. The contents of this course consist of a few topics on instructional strategies and objectives, while none of the other processes of Mathematics Education are included. The possible reason for the emphasis on the senior primary classes is that the first year is considered to be a general course and students have the option of being able to change to the DE (Senior Primary) course.

The Subjects Didactics for the first year is not examinable and this could result in possible neglect.

(b) Second Year

The second year Subject Didactics is aimed at preparing the

student for the junior secondary level. An in-depth study of the aims, content and lesson structure of Mathematics for the junior secondary level is prescribed with specific emphasis on preparation of lessons and the use of teaching aids. Some of the topics included are based on the pre-1984 secondary school Mathematics syllabi.

The nature of Mathematics, the intellectual development of pupils and how pupils learn various categories of content are the three processes of Mathematics Education that are not included in the Subject Didactics course for the second year. In my opinion, too much emphasis is given to instructional strategies and administrative procedures.

(c) Third Year

This year of study emphasizes the aims and contents of the Mathematics syllabus for Standard 8, but still includes outdated topics based on the pre-1984 secondary school Mathematics syllabi.

Topics based on 5 of the 6 aspects of the process of teaching Mathematics (see Fig.2 on p.44) are prescribed but there is no indication of the inter-relationship of these aspects. Topics of an administrative nature already dealt with in the second year of study as well as instructional strategies are

again emphasized.

(d) Fourth Year

This year of study includes a few optional Subject Didactics topics that are not examinable. The aspect, Objectives Specified, of the process of teaching Mathematics is again not specifically prescribed and instructional strategies are again emphasized. The inter-relationship of the aspects of the process of teaching Mathematics is not evident from the selection of topics.

Approaches to outdated secondary school Mathematics topics are again included and would be of very little use to the beginning teacher. Some of the optional topics have direct bearing on the new secondary school Mathematics syllabi and have not been dealt with during previous years of study.

At least three projects relating to topics as prescribed for Subject Didactics are required for the fourth year of study. A list of references for the prescribed topics is not included in the syllabi for the different years of study.

The above overview of the Subject Didactics syllabi prescribed for the four-year HDE (Secondary) course for Mathematics teachers shows that the prescribed topics for the

different years of study are not carefully inter-related and no specific model for the different processes of Mathematics Education is prescribed. This course is based on the pre-1984 secondary school Mathematics syllabi and includes teaching methods of topics not in the existing secondary school syllabi.

RECOMMENDATIONS:

- (1) The Subject Didactics syllabi for the four-year HDE (Secondary) course should be revised so as to be relevant to the Mathematics taught at secondary school level.
- (2) With the revision of the Subject Didactics syllabi for the four years of study, consideration should be given to applying a specific model that illustrates the inter-relationship of the different processes of Mathematics Education.
- (3) A list of suitable and easily accessible references for the different topics should also be included in the syllabi for the different years of study.
- (4) The teaching of content and method of Mathematics should be integrated and not dealt with in isolation.
- (5) More of the lecturing time allocated for Mathematics should be utilized for the teaching of Subject Didactics.

- (6) The teaching of the Subject Didactics section of the Mathematics syllabi should rather be assigned to lecturers with an adequate and relevant knowledge of Mathematics Education.

6.1.7 Mathematics Content

All the Mathematics lecturers in their responses agreed that prospective secondary school Mathematics teachers require knowledge of the subject beyond matric level. Most lecturers and teachers in their responses indicated that sufficient mathematical content is prescribed for the pre-service training of secondary school Mathematics teachers and only a few lecturers suggested additional topics that could be included for the pre-service training.

Apart from the textbooks for secondary school Mathematics, only textbooks on calculus are prescribed by most of the colleges of education.

From the responses of the lecturers to questions on topics from the secondary school Mathematics syllabus it appears that most lecturers are not familiar with the content changes as well as the changes of emphasis on functions and euclidean geometry. This could be due to the fact that the present

Mathematics syllabus for the HDE (Secondary) course was based on the pre-1984 school syllabus and contains topics from this outdated syllabus. Another reason could be that most lecturers are not familiar with guidance given on the new syllabus to secondary school teachers by the subject advisers.

The depth of treatment of topics in the syllabus for the HDE (Secondary) course is not specified and could result in lecturers and examiners having different interpretations. Lists of suitable references on the prescribed topics as well as possible textbooks are not included in the syllabi for the four years of study. An analysis of the mathematical content of the HDE (Secondary) Mathematics syllabus for the four years of study can be summarized as follows (also see Appendix D):

(a) First Year

This syllabus consists of two modules and is based on the pre-1984 Standards 9 and 10 Higher Grade Mathematics syllabus. The first module is basically a revision of some standard 9 and 10 school Mathematics consisting of mathematical induction, relations and functions, linear and quadratic equations and inequalities, and linear programming.

The second module contains some trigonometry and geometry. The euclidean geometry prescribed is a revision of Standard 7, 8 and 9 work, while the trigonometry is a revision of Standard 9 Higher Grade work.

The first year of study consists of a revision of some secondary school Mathematics and the only additional topic not included in the pre-1984 secondary school syllabus is a section on linear programming. The topics prescribed for the first year of study do not cover the full spectrum of Mathematics prescribed for the senior secondary standards.

(b) Second Year

This year of study only involves one module on mathematical content which contains sections on algebra, trigonometry and analytic geometry, while no further euclidean geometry is prescribed.

The algebra is a continuation of the work prescribed for the first year and covers the sections of the pre-1984 senior secondary Mathematics not dealt with in the first year. Three additional topics are included, namely, elimination, synthetic division and the remainder theorem.

The trigonometry is a continuation of the first year work and

deals with the remainder of the senior secondary Mathematics not prescribed for the first year. The analytic geometry prescribed is based only on the properties and equations of straight lines.

The second year of study does not contain post-matric Mathematics topics. The senior secondary school Mathematics syllabus has also not been adequately covered up to this year of study.

(c) Third Year

The syllabus for this year of study consists of two modules. The one module consists of algebra and analytic geometry, while the other consists of differential calculus and some trigonometry.

The first module contains the following topics: permutations and combinations, binomial theorem, matrices and determinants. The analytic geometry prescribed refers to the following curves: circle, parabola, ellipse and hyperbola. The depth and detail of the prescribed topics for analytic geometry is not specified.

The second module contains the following topics on differential calculus: limits; continuity; gradients;

derivatives of polynomials, exponential functions, trigonometric and inverse trigonometric functions; implicit differentiation; Rolle's theorem; second order derivatives; applications to graphs of functions and optimization problems. The trigonometry prescribed for this module consists of the following: radian measure; arc length; area of a sector; graphical representation of the inverse trigonometric functions.

(d) Fourth Year

The syllabus for this year of study consists of two modules. A few non-examinable topics are also included.

The first module includes the following topics: statistics; probability; logic; vectors; complex numbers; roots of cubic equations; infinite series; infinite sequences; partial fractions; polar coordinates; inverse trigonometric functions; Euler's polyhedron formula. The additional non-examinable topics include introductory topics: Bayes' rule, curve tracing and transformations in polar coordinates, spherical trigonometry, tessellations and transformation geometry.

The second module deals with limits; continuity and elementary integral calculus. The concepts of limits and

continuity as prescribed for the third year of study are again included, but with emphasis on formal definitions and applications. The topics on integral calculus include the following: concept of area; trapezium rule; definite integral; indefinite integral; fundamental theorem of calculus; integration techniques; and areas of laminae.

The integral calculus prescribed for this year of study is equivalent to that in most first year university courses. A number of universities have exempted students who have passed this course from repeating the first year Mathematics course.

RECOMMENDATIONS :

- (1) The Mathematics syllabus for the HDE (Secondary) course should be revised, considering the criteria for the minimum qualifications for secondary school Mathematics teachers, as well as its relevance to secondary school Mathematics.
- (2) The revised syllabi for the four years of study should be at least equivalent to second year university level.
- (3) The secondary school Mathematics syllabus must be considered when revising the syllabus, but a revision of secondary school Mathematics topics should not be the only component of the first year of study. The first

year of study should rather be a continuation of school Mathematics.

- (4) Specific details relating to the depth of treatment of each topic should be specified in the syllabus.
- (5) With the revision of the syllabus the contents of future secondary school Mathematics syllabi must be borne in mind.
- (6) A list of recommended references for each topic as well as possible prescribed textbooks should be included in the syllabus.
- (7) The Education Department should arrange courses for Mathematics lecturers and examiners to assist with the interpretation of the revised syllabus for the HDE (Secondary) course before its introduction.

6.1.8 Micro-computers

Computer literacy courses are included in the training of all HDE (Secondary) students at colleges of education using the Commodore 64 system. The responses of the lecturers show that most of them are computer literate, to a certain extent, but only a small percentage of lecturers are directly involved with the computer literacy courses and only a few lecturers have actually used computers to assist with the

teaching of Mathematics. All the lecturers agreed that micro-computers have a useful role to play in the teaching of Mathematics and that it is necessary for prospective Mathematics teachers to have some knowledge of micro-computers.

The responses of the teachers on the other hand show that only a small percentage of beginning teachers are computer literate and none of these teachers have used micro-computers for the teaching of Mathematics. Possible reasons why micro-computers have not yet been used by beginning teachers for the teaching of Mathematics could be that the schools at which they are teaching have not yet been supplied with micro-computers or that suitable software is not yet available.

The facilities for exposing prospective secondary school Mathematics teachers to micro-computers are available at all the colleges of education, but it appears that suitable software for use in the Mathematics classroom is not yet available for the installed systems.

RECOMMENDATIONS:

- (1) The Education Department must explore ways of finding or developing suitable software for use in the Mathematics

classroom and should supply all the colleges with such software material.

- (2) A course on the use of micro-computers in the Mathematics classroom should be arranged for all Mathematics lecturers at colleges of education so that they can expose their students to the value and place of micro-computers in the Mathematics classroom.
- (3) The role and use of micro-computers in the Mathematics classroom including exposure to available software should be considered when the Subject Didactics syllabus for secondary school Mathematics teachers is revised.

6.2 RECOMMENDATIONS FOR FUTURE RESEARCH

Future research on the pre-service training of secondary school Mathematics teachers at colleges of education could also include the views of subject advisers, inspectors of education, examiners, supervising teachers for practice teaching and subject heads at secondary schools.

At the other extreme of the spectrum it is necessary to test the views of students who are actually being subjected to the present system of secondary school Mathematics teacher training at colleges of education.

One of the most urgent aspects of my investigation that requires further exploration is the relevance of college Mathematics syllabi to the needs of prospective secondary school Mathematics teachers.

As stipulated in the research design, the present investigation reveals trends in the Eastern Cape and Natal and this leaves open a profitable field of investigation along similar lines among beginning secondary school Mathematics teachers in the Western Cape, where the bulk of the so called 'Coloured' secondary schools are to be found. The present investigation can provide no more than pointers of what may be representative of the total population of beginning secondary school Mathematics teachers.

The data regarding the number of Mathematics students following the HDE (Secondary) course was adequate for many of my purposes, but had shortcomings when it came to analysing growth of student numbers and drop-out rates. Future related research could consider statistics of more recent intakes of prospective secondary school Mathematics teachers, resulting in more conclusive findings on the effectiveness of the HDE (Secondary) course for prospective secondary school Mathematics teachers.

6.3 RECOMMENDATIONS FOR MATHEMATICS EDUCATION

Mathematics teacher education must be accepted both as pre-service preparation and a professionalization process which continues through the career of the teacher. Mathematics teachers must be capable of diagnosing learning problems, developing curricular materials, experimenting with instructional procedures appropriate to the needs of a wide range of individuals, and evaluating the outcomes of these activities. The complexities and responsibilities of the Mathematics teacher's role are obvious. Yet, an analysis of the graduate preparation of most Mathematics teacher educators discloses that few have participated in programmes specifically designed to meet these complexities and demands.

Mathematics teacher educators must become more knowledgeable about, and sensitive to, the relationship of their own speciality to all other speciality areas in the professional preparation of Mathematics teachers. This can be accomplished by a broad foundational experience in pedagogy and the supporting disciplines, designed to provide Mathematics teacher educators with an awareness of the contributions of Mathematics to the broad context of teacher preparation. Without such background, Mathematics teacher educators will leave to each prospective Mathematics teacher

the daunting task of integrating the miscellany of learnings into a coherent whole. The education of Mathematics teacher educators is largely ignored in the professional literature. The education of Mathematics teacher educators should emerge principally from the needs of prospective Mathematics teachers whom they prepare.

It is clearly important that prospective Mathematics teachers should feel that all parts of their pre-service training are relevant to their needs. The relevance of courses on methods of teaching and classroom organization is clear, as is the relevance of school experience, but the relevance of education theory may be less apparent, because some Mathematics teacher educators have an inadequate background of Mathematics teaching. There is a need for close co-operation between Mathematics educators and Pedagogics lecturers so that education theory can be seen by prospective Mathematics teachers to be firmly grounded on practice in schools and to be a valid and necessary contribution to their pre-service training.

6.4 CONCLUSION

This study of the pre-service training of secondary school Mathematics teachers at colleges of education under the

control of the House of Representatives shows that the education system followed is unfortunately still in an early stage of development. The findings also show that the Mathematics teacher educators at these institutions are mostly not suitably qualified and that the HDE (Secondary) course appears to be rather unpopular.

The prescribed Mathematics syllabus for the HDE (Secondary) course is found to be not fully suitable for the pre-service training of secondary school Mathematics teachers and a revision thereof should be seriously considered. On the other hand, the Education Department should rather reconsider its present policy of training secondary school teachers at colleges of education and leave such training to the universities, recognised by law and capable of providing the relevant educational function of training secondary school teachers.

I wonder how many people were taught by a Mathematics teacher whom they loved and respected; one who helped them in many areas; but one who unfortunately was a person who feared Mathematics or disliked it? Until we get a generation of children who are happy in Mathematics, with teachers who are happy teachers of Mathematics, then there is little likelihood that we can change the public attitude towards Mathematics.

Mathematics teachers must develop many competencies to lead school children to desirable achievement levels in Mathematics as well as to promote positive attitudes toward the subject. These competencies are developed not only through the study of selected topics in pre-service method courses but also in in-service training sessions.

If we wish to take seriously the education of Mathematics teachers, we have a responsibility to reflect seriously upon what that special knowledge is, which permits the development of professional Mathematics teachers and to consider what processes exist when teachers acquire that knowledge. The process of educating the professional Mathematics teacher is too important to allow ourselves to be moved by whimsical educational theories.

It is the responsibility of those who train Mathematics teachers to ensure that prospective teachers experience a wide variety of teaching methods, and start teaching with an ability to use these methods in their teaching. Teachers who are better prepared for their profession, assure better education.

There is no doubt that the most important resource for good Mathematics teaching is an adequate supply of competent Mathematics teachers guided by equally competent trainers.

The hope is hereby expressed that this study will contribute not only to the improvement of the training of secondary school Mathematics teachers at colleges of education administered by the House of Representatives, but also to the improvement of the training of all Mathematics teachers in the RSA.

APPENDIX A

QUESTIONNAIRE A

GENERAL INFORMATION

(To be completed by the Head of the Mathematics Department)

NAME OF THE COLLEGE:

STATISTICAL DETAILS

QUESTION 1: Please indicate in the table below, the number of students offering Mathematics as one of their subjects for the various courses.

NAME OF COURSE	Number of students taking Mathematics as a subject during the years:				
	1986	1985	1984	1983	1982
(a) HDE (SECONDARY)					
(b) HDE (SENIOR PRIMARY)					
(c) HDE 3 (SECONDARY)					
(d) DE 3 (SENIOR PRIMARY)					
(e) HDE 2 (SECONDARY)					
(f) DE 2 (SENIOR PRIMARY)					
(g) HDÉ I (SECONDARY)					
(h) DE I (SENIOR PRIMARY)					
TOTALS					

QUESTION 2

Please complete the table below, regarding the Mathematics lecturers.
(NAMES OF LECTURERS ARE NOT REQUIRED)

LECTURERS	Academic Qualifications. State degree and year e.g. B.Sc (1982)	Professional qualifications. State Diploma and/or degrees e.g. S.T.D. (1983)	State the number of University Courses in Mathematics. Indicate Post-graduate training in Mathematics e.g. Maths 11	State (Yes/No) whether a University method course in Mathematics was successfully completed	State experience in years as a College Lect.	State experience in years at a Sec. School	State other experience	State the groups or courses that lecturer is instructing this year
LECTURER A (Head of the Mathematics Department)								
LECTURER B								
LECTURER C								
LECTURER D								
LECTURER E								
LECTURER F								

QUESTION 3: Please indicate the number of lecturing periods allocated to Mathematics on the table below:

COURSE	Number of lecturing periods allocated weekly to each of the following sections:			
	Content	Didactics	Tutorials	Total
(a) H.D.E. 1V				
(b) D.E. 111				
(c) D.E. 11				
(d) D.E. 1				

RESOURCES FOR TEACHING MATHEMATICS

QUESTION 4: The following question relate to the resources for teaching Mathematics at your College.

(please delete which is not applicable)

4.1 Are prescribed textbooks used for the Content Section of the syllabus? YES NO

If you answered Yes, please write down the titles and authors in the space below:

.....

4.2 Are prescribed textbooks used by the students for the Method section of the syllabus? YES NO

If you answered YES, please write down the titles and authors in the space below:

.....

4.3 Are any study material/lecture notes/handouts on topics from the Method (Didactics) section issued to the students? YES NO

4.4 Does your College have a classroom(s) or laboratory equipped for teaching Mathematics? YES NO

4.5 Do the lecturers of Mathematics have their own subjectrooms? YES NO

4.6 Does your College subscribe to Journals or Publications on Mathematical Education? YES NO

If you answered YES, please list the publications in the space below:

.....

4.7 Are suitable textbooks for the use by students and lecturers on the Teaching of Mathematics available in your library? YES NO

If you answered YES, please list the titles and authors on a separate sheet. Perhaps your librarian will help.

4.8 Are special funds available for acquiring teaching aids/material for Mathematics? YES NO

4.9 Are any teaching apparatus/aids/material for Mathematics supplied by the Department of Education and Culture? YES NO

4.10 Are the students required to construct teaching aids for their teaching of Mathematics? YES NO

5.4 Is the Mathematics Department at your College involved with assistance to Secondary or Primary school pupils? YES NO

PROFESSIONAL PREPAREDNESS

QUESTION 5: (Please delete which is NOT applicable)

5.1 (a) With the introduction of the current syllabi for the various Mathematics courses as offered at your College, were any refresher courses held by the Education Department for the lecturers? YES NO

5.1 (b) Do the lecturers of Mathematics at your College consult with lecturers of other Colleges on syllabi interpretation and sharing of ideas? YES NO

If you answered YES, how is this done?
Use the space below:

.....
.....
.....
.....

5.2 Are Mathematics Subject meetings held by the Head of the Mathematics Department? YES NO

If you answered YES, state how frequent:

.....
.....

5.3 Is this College involved with the in-service training of Mathematics teachers? YES NO

If you answered YES, give details in the space below:

.....
.....
.....
.....

If you answered YES, give some details in the space below:

.....
.....
.....
.....

5.5 Do the lecturers of Mathematics at this college meet with the Mathematics Subject Advisers of the Department? YES NO

If you answered YES, on what basis?

.....
.....
.....
.....

5.6 Is the Mathematics Department affiliated to a Mathematical Association? YES NO

If you answered YES, name the Association(s):

.....
.....
.....

THANK YOU FOR YOUR CO-OPERATION

APPENDIX B

QUESTIONNAIRE B

TO BE COMPLETED BY INDIVIDUAL MATHEMATICS LECTURERS (INCLUDING THE HEAD OF DEPARTMENT)

PLEASE NOTE THAT YOU ARE NOT REQUIRED TO GIVE YOUR NAME.

PLEASE COMPLETE THE FOLLOWING QUESTIONS AND DELETE WHERE NOT AFFLICABLE

PERSONAL DETAILS

AGE:

ACADEMIC QUALIFICATIONS:

PROFESSIONAL QUALIFICATIONS:

TEACHING EXPERIENCE IN MATHEMATICS (State years):

 PRIMARY SCHOOL:

 SECONDARY SCHOOL:

 TERTIARY:

 OTHER (State):

QUESTION 1: (Please delete where NOT applicable)

- | | | | |
|-----|---|-----|----|
| 1.1 | Did you offer Mathematics as a major for your degree? | YES | NO |
| 1.2 | Did you offer Method of Mathematics as a subject for your professional qualification? | YES | NO |
| 1.3 | Are you currently involved with further studies in: | | |
| | 1.3.1 Mathematics | YES | NO |
| | 1.3.2 Mathematical Education? | YES | NO |
| 1.4 | Have you offered any mathematically related subjects for any of your degrees? | YES | NO |
| | If YES, please state the subjects: | | |
| | | | |
| | | | |

QUESTION 2: The following questions relate to your interest in the teaching of Mathematics.

(Please delete which is NOT applicable)

- | | | | |
|-----|--|-----|----|
| 2.1 | Are you affiliated to any Mathematical Association? | YES | NO |
| | If YES, please name the association and state the number of years of membership | | |
| | | | |
| | | | |
| 2.2 | Have you attended any of the National Conventions for Mathematics teachers held by the Foundation of Science, Education and Technology? | YES | NO |
| 2.3 | Have you attended any of the conferences of the Mathematical Association of South Africa? | YES | NO |
| 2.4 | What does ICME, stand for? | | |
| | | | |
| 2.5 | Have you attended any of the ICME congresses? | YES | NO |
| 2.6 | Are you familiar with the guidance material issued by the Mathematics Subject Advisers to Secondary teachers of Mathematics? | YES | NO |
| 2.7 | Have you attended any of the various short courses held by the Mathematics Subject Advisers for Secondary teachers? | YES | NO |
| 2.8 | Do you think that a conference discussing the training of Mathematics teachers and the interpretation of the prescribed syllabi, will be of any help to you? | YES | NO |
| 2.9 | Have you ever assisted a school pupil in preparing for a Mathematics Olympiad? | YES | NO |

RESOURCES, TEACHING AIDS

QUESTION 3: This question relates to teaching aids, materials and resources used for the teaching of Mathematics.

(Please delete which is NOT applicable)

3.1 In your personal library, which is the main reference work that you use for the teaching of Mathematics Subject Didactics?

.....

3.2 Do you personally subscribe to any journals or publications on the teaching of Mathematics? YES NO

3.3 Please indicate using a tick ✓ whether the following publications are used by you: YES NO

- (a) Spectrum
- (b) The Mathematics Teacher
- (c) Mathematics Teaching
- (d) Mathematical Digest
- (e) Pythagoras
- (f) IMSTUS NEWS
- (g) The Journal of the Natal Teachers' Mathematics Association
- (h) Please name any other used by you, but not listed above

YES	NO

3.4 Would a recommended list of suitable reference material for the use of teaching Subject Didactics be of any use to you? YES NO

QUESTION 4: The following questions relate to the role and use of COMPUTERS IN THE TEACHING OF MATHEMATICS

(Please delete where NOT applicable)

4.1 Do you think that computers can be useful for the teaching of Mathematics at school? YES NO

4.2 Do you think that it is necessary for a teacher of Mathematics to have some knowledge of the use of micro-computers? YES NO

4.3 Do you use computers to assist you with the teaching of Mathematics? YES NO

4.4 Do you assist the students at your College during their sessions in the Computer room? YES NO

4.5 Do you know how to operate a micro-computer? YES NO

If YES, please state the training that you received. Use the space below:

.....

4.6 Do you have any knowledge of Programming? YES NO

If YES, state the language that you are familiar with:

.....

4.7 Would you be interested in attending a course specifically designed to explain the role and use of micro-computers in the Mathematics classroom? YES NO

QUESTION 5: The following questions relate to the training of Mathematics teachers:

- 5.1 Are specific lecturing time set aside by you for the teaching of Subject Didactics? YES NO
- 5.2 Is research on the teaching of Mathematics useful? YES NO
- 5.3 Do you find it necessary for any trainer of student-teachers of Mathematics to have any teaching experience at school level? YES NO
- 5.4 Is knowledge of Mathematical content beyond matric level necessary for the training of Secondary school teachers of Mathematics? YES NO
- 5.5 Which school subjects, in addition to Mathematics, do you feel should also be offered by prospective mathematics teachers?
.....
.....
.....
- 5.6 Are there any additional topics on Mathematics that you feel should also have been included in the syllabi for the initial training of secondary teachers of Mathematics? YES NO
If YES, please specify in the space below:
.....
.....
.....
.....

MATHEMATICAL CONTENT

QUESTION 6: The following questions relate to some topics from the Content of Mathematics as prescribed in the various syllabi:

(Please delete where NOT applicable)

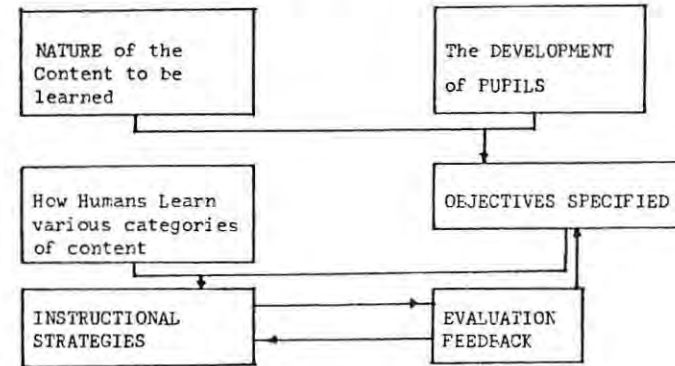
- 6.1 Give some reasons why you think it is necessary to revise school syllabi in Mathematics from time to time. Use the space below:
.....
.....
.....
- 6.2 Is an AXIOM a self-evident truth? YES NO
- 6.3 What are the reasons for including Euclidean Geometry in the school syllabi?
.....
.....
.....
- 6.4 Name some other topics in Mathematics that could also have been used to teach the Axiomatic - Deductive structure of Mathematics to school pupils?
.....
.....
.....
- 6.5 Write down a suitable definition for the concept of a FUNCTION that you will use at school level, based on the new syllabus (1984)
.....
.....
.....
.....

MATHEMATICAL EDUCATION (Please delete where NOT applicable)

QUESTION 7: The following questions are based on topics from the Method section of the various syllabi:

- | | | | |
|-----|---|-----|----|
| 7.1 | Do you frequently refer to the study material given to you during your Mathematics Method course? | YES | NO |
| 7.2 | Will the use of electronic calculators at school inhibit a pupil's mathematical development and reasoning? | YES | NO |
| 7.3 | Are you satisfied with the topics prescribed for the teaching of Subject Didactics of Mathematics? | YES | NO |
| 7.4 | Name some topics that you teach to your students that are not specifically prescribed in the various syllabi on Subject Didactics.
.....
.....
..... | | |
| 7.5 | Are there topics that you feel should be excluded from the prescribed syllabi for the teaching of Subject Didactics? | YES | NO |
| 7.6 | Would a textbook based on all the topics as prescribed in the Subject Didactics syllabi be used by you as main reference? | YES | NO |

QUESTION 8: The Process of Teaching Mathematics can be illustrated as in the diagram below (Farrell and Farmer)



A few sections taken from the H.D.E. (Secondary) syllabus are listed below.

Use the attached sheet and complete the table.

Relate each of the following topics to the above aspects of the process of teaching Mathematics.

- TOPIC A: The social, economic, intellectual and emotional factors influencing the pupil's attitude towards the subject. (Syllabus ref. 3)
- TOPIC B: Number sense. i.e. Man's ability to quantify (Syllabus ref. 4)
- TOPIC C: The history of the development of Mechanical aids for calculations. (Syllabus ref. 7.9)
- TOPIC D: A discussion of the contributions made by the GREEKS, EGYPTIANS and ARABS to the development of Mathematics. (Syllabus ref. 7.10)
- TOPIC E: The slow learner. Didactic remediation
- TOPIC F: The teaching of worded problems in Algebra. (Syllabus ref. 8.8)
- TOPIC G: Evaluation: Tests and Examinations. (Syllabus ref. 11)
- TOPIC H: Schemes of work for Secondary Mathematics Syllabi (Syllabus ref. 10)

PLACE A TICK ✓ IN THE APPROPRIATE COLUMN

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	TOPIC A	TOPIC B	TOPIC C	TOPIC D	TOPIC E	TOPIC F	TOPIC G	TOPIC H
THE NATURE OF THE CONTENT TO BE LEARNED								
THE DEVELOPMENT OF PUPILS								
OBJECTIVES SPECIFIED								
HOW HUMANS LEARN VARIOUS CATEGORIES OF CONTENT								
ISTRUCTIONAL STRATEGIES								
EVALUATION FEEDBACK								

THANK YOU FOR YOUR CO-OPERATION

APPENDIX C

QUESTIONNAIRE C

TO BE COMPLETED BY PRACTICING SECONDARY SCHOOL MATHEMATICS TEACHERS IN THEIR FIRST THREE YEARS OF TEACHING.

PLEASE NOTE THAT ALL DETAILS WILL BE TREATED IN THE STRICTEST CONFIDENCE AND RESPONDENTS ARE NOT REQUIRED TO GIVE THEIR NAMES.

PLEASE ANSWER THE FOLLOWING QUESTIONS AND DELETE WHERE NOT APPLICABLE

PERSONAL DETAILS

AGE:

SEX: MALE/FEMALE

COLLEGE OF EDUCATION WHERE YOU RECEIVED YOUR TRAINING:

PROFESSIONAL QUALIFICATIONS:

ACADEMIC QUALIFICATIONS:

HOME LANGUAGE: ENGLISH/AFRIKAANS/OTHER

STATE THE NUMBER OF YEARS TEACHING EXPERIENCE IN MATHEMATICS:

WHICH OTHER SCHOOL SUBJECT(S) DID YOU ALSO OFFER AS A MAJOR FOR THE COURSE YOU FOLLOWED AT COLLEGE?:

SINCE COMPLETION OF YOUR INITIAL TRAINING AT A COLLEGE OF EDUCATION, HAVE YOU COMPLETED ANY OTHER COURSE? YES NO

If YES, give some details. Use the space below.

WHAT WAS THE SYMBOL YOU ATTAINED FOR MATHEMATICS FOR THE SENIOR CERTIFICATE?

QUESTION 1

Please delete which is NOT applicable

1.1 To which standards at secondary school level have you taught Mathematics? Standards 6/7/8/9/10

1.2 Did you follow a teaching course with the specific intention of being a Mathematics teacher? YES NO

If NO, state why. Use the space below.

1.3 State other school subjects that you have taught at secondary school level. Use the space below.

1.4 Do you feel confident enough to teach Mathematics to secondary school pupils? YES NO

1.5 Are you affiliated to any Mathematical Association? YES NO

If YES, please name the association and state the number of years of membership.

1.6 Do you subscribe to local publications/journals on the teaching of Mathematics? YES NO

1.7 Do you relate Mathematics to other school subjects when teaching Mathematics? YES NO

QUESTION 2

THE FOLLOWING QUESTIONS RELATE TO THE ROLE AND USE OF COMPUTERS
IN THE TEACHING OF MATHEMATICS

Please delete where NOT applicable

- 2.1 Do you know how to operate a micro-computer? YES NO
 IF YES, please state the training that you received. Use the space below.

- 2.2 Do you have any knowledge of Computer Programming? YES NO
- 2.3 Do you use computers to assist you with the teaching of Mathematics? YES NO
- 2.4 Do you think that computers can be useful for teaching Mathematics? YES NO
- 2.5 Do you think that it is necessary for a Mathematics teacher to have some knowledge of the use of micro-computers? YES NO
- 2.6 Only answer the following question if you followed a Computer Literacy course at one of the Colleges of Education:
- 2.6.1 Did you find the Computer Literacy course that you followed useful? YES NO
- 2.6.2 Have you written any programs for the use in the Mathematics classroom? YES NO

QUESTION 3

THE FOLLOWING QUESTIONS RELATE TO THE INITIAL TRAINING COURSE FOLLOWED AT A COLLEGE OF EDUCATION:

Please delete where NOT applicable

- 3.1 Was the Mathematical Content taught to you at College sufficient for your teaching of Mathematics at secondary school level? YES NO
- 3.2 Did you find the Subject Didactics of Mathematics taught to you at College of any value? YES NO
- 3.3 Do you feel that enough Subject Didactics of Mathematics were imparted to you at College? YES NO
- 3.4 Should more lecturing time have been allocated to the section on Subject Didactics of Mathematics? YES NO
- 3.5 Did you find the subject Didactics course on Mathematics interesting? YES NO
- 3.6 Has the Subject Didactics course inspired you to further your study of the teaching of Mathematics? YES NO
- 3.7 Did you use a prescribed textbook(s) for the section on Subject Didactics for Mathematics? YES NO
- 3.8 Did you receive any study material on the teaching of Mathematics from your lecturer(s)? YES NO
- 3.9 Did the college of education that you attended have any useful reference material on the Teaching of Mathematics in their library? YES NO

QUESTION 4

THE FOLLOWING QUESTIONS RELATE TO THE INITIAL TRAINING COURSE
FOLLOWED AT A COLLEGE OF EDUCATION

Please delete where NOT applicable

- 4.1 Did you make any teaching aids for Mathematics as part
of your training at College? YES NO
- 4.2 Did your lecturer at College use teaching aids for
Mathematics? YES NO
- 4.3 Are you using many of the lecturer's methods of
teaching Mathematics for your teaching at secondary
school? YES NO
- 4.4 Were proposed schemes of work for the secondary
syllabi for Mathematics discussed with you at
College? YES NO
- 4.5 Were the current syllabi for Mathematics at school
level discussed during the Subject Didactics
lectures? YES NO
- 4.6 Was attention given to the teaching of Mathematics
to special students (Mathematically talented and
slow learners)? YES NO
- 4.7 State briefly your impressions of the Subject
Didactics course in Mathematics offered to you
at the college of education you attended.
Use the space below.

.....
.....
.....
.....
.....

THANK YOU FOR YOUR CO-OPERATION

APPENDIX D

MATHEMATICS SYLLABUS HIGHER DIPLOMA IN EDUCATION

HOUSE OF REPRESENTATIVES DEPARTMENT OF EDUCATION AND CULTURE

AIMS

1. To give the students a thorough knowledge, insight and skill in the basic mathematical principles
2. To extend the students background, to deepen their insight and to develop their appreciation for the logic and structure of Mathematics and to equip them so that they will be able to teach Mathematics with confidence and enthusiasm
3. To expose the students to mathematical thinking; so that it gives them pleasure
4. To arouse the students interest in further study in Mathematics and other related subjects.

REMARKS

1. For the sake of convenience the subject matter has been divided into different sections

The subject matter should as far as possible be integrated and treated concurrently in order to retain the unity of the subject

The arrangement of the content is not necessarily an indication of the sequence in which the subject matter should be treated
2. The subject matter mentioned in this syllabus should be presented and mastered at such a level that students will not encounter problems when teaching the corresponding subject matter in the syllabuses of the primary and secondary schools
3. Where possible the student must be led to apply their mathematical knowledge in the formulation and solution of real life problems i.e. students must be exposed to simple mathematical modelling
4. Where possible the subject matter and method of presentation should be dealt with simultaneously
5. During the teaching of the subject the different approaches with regard to the intuitive-experimental in contrast to the formal-deductive approach should be clarified

As regards the formal-deductive approach, accurate formulation and the essential difference between definitions, axioms, theorems and applications should be stressed

6. POCKET CALCULATORS

Students are allowed to use calculators for classwork and during examinations

Calculators must be silent, cordless and non-programmable

No restrictions are placed on the functions capable of being performed by the calculator but no external storage media (i.e. magnetic strip programmes) may be brought into the examination room

7. The introduction of a tutorial system is recommended

One period a week should be set aside for the purpose of tutorials

Tutorials must afford opportunity for the consolidation and application of mathematical concepts by means of assignments which students must do under the supervision and guidance of the lecturer

At all times the purpose of the tutorial must be to identify and solve the problems of individual students

8. Whenever possible the workshop idea should be used

It is desirable that students should work through the material they are to present at school in the same way as pupils would be expected to work through the material

D.1 SYLLABUS: FIRST YEAR**D.1.1 MODULE 1: ALGEBRA****D.1.1.1** Number concept

Summary of the operations and the operational rules in the different number sets as point of departure for the following:
The principle of Mathematical Induction with simple applications to the summation of series

D.1.1.2 Relations and functions**D.1.1.2.1** Definitions and applications

relations; functions; domain; range; variable; dependent and independent variables

D.1.1.2.2 The inverse of a function with special reference to the functions defined by

$$y = ax + b ; \quad y = ax^2 \quad ; \quad y = a(x - p)^2$$

D.1.1.2.3 Function of a function**D.1.1.2.4** The deduction of the characteristics with regard to domain, range, intercepts with axes, form and symmetry from the equation and the graphical representation of functions and relations (no point by point plotting required for examination purposes) with special reference to the following (x and y real):

$$\{(x;y) : ax + by + c = 0\} \quad ; \quad \{(x;y) : x^2 + y^2 = r^2\}$$

$$\{(x;y) : y = ax^2 + bx + c\} \quad ; \quad \{(x;y) : xy = k\}$$

$$\{(x;y) : y = |ax + b|\} \quad ; \quad \{(x;y) : x = ay^2 + by + c\}$$

D.1.1.2.5 Equations and inequalities with regard to relations from 2.4 including:

$$\{(x;y) : y \geq \pm \sqrt{r^2 - x^2}\}$$

$$\{(x;y) : y \geq \frac{k}{x}\}$$

$$\{(x;y) : y \geq |ax + b|\}$$

D.1.1.3 Solution sets

N.B. Factorization is assumed as previous knowledge

D.1.1.3.1 Linear equations and inequalities

- (a) The solution of simple and difficult problems by means of linear equations and inequalities in one unknown:

- D.1.1.3.1 (b) Applications of systems of linear equations for the solution of simple problems (only two unknowns)

- (c) Linear programming as application of graphic representation of linear inequalities

D.1.1.3.2 Quadratic equations and inequalities

- (a) The roots of $ax^2 + bx + c = 0$; conditions for solution in the set of real numbers; equal and unequal roots; rational and irrational roots; imaginary roots; the sum and the product of the roots

- (b) The solution set of $ax^2 + bx + c \geq 0$

- (c) Solution of two simultaneous equations (in two variables) of which one is of the first degree and the other of the second degree

- (d) Problems which lead to quadratic equations and inequalities of the following types e.g. numbers; age; length and area; time; distance and speed; price calculations

D.1.2 MODULE 2: SYNTHETIC GEOMETRY

The following geometric facts must be illustrated experimentally and used as axioms in problem solving:

- D.1.2.1 If two lines intersect, then the sum of any pair of adjacent angles is equal to 180°

- D.1.2.2 If two lines intersect then the vertically opposite angles are equal

- D.1.2.3 If two parallel lines are intersected by a transversal then

- D.1.2.3.1 the alternate angles are equal

- D.1.2.3.2 the corresponding angles are equal

- D.1.2.3.3 the sum of the interior angles on the same side of the transversal is equal to 180°

- D.1.2.3.4 The converse of 3.1, 3.2 and 3.3

- D.1.2.4 The exterior angle of a triangle is equal to the sum of the interior opposite angles

- D.1.2.4.1 The sum of the three inner angles of a triangle is equal to 180°

- D.1.2.5 The four cases of congruency of triangles

- D.1.2.6 The base angles of an isosceles triangle are equal, and the converse
- D.1.2.7 The opposite sides and angles of a parallelogram are equal, the diagonals bisect each other and each diagonal bisect the area of the parallelogram
- D.1.2.8 The diagonals of a rectangle bisect each other
- D.1.2.9 The diagonals of a rhombus bisect each other perpendicularly and bisect the angles of the rhombus
- D.1.2.10 The theorem of Pythagoras and its converse
- D.1.2.11 The line joining the centre of a circle to the centre of a chord is perpendicular to the chord
- D.1.2.11.1 The line through the centre of a circle perpendicular to the chord bisects the chord
- D.1.2.11.2 The perpendicular bisector of a chord passes through the centre of the circle
- D.1.2.12 The angle subtended by an arc at the centre of the circle is twice the angle it subtends at any other point on the circle
- D.1.2.13 Angles in the same segment are equal
- D.1.2.14 The angle in a semi-circle is a right angle (Theorem of Thales)
- TRIGONOMETRY
- N.B.: Items 1.2.15 - 1.2.19 for angles in the interval $[0^\circ ; 360^\circ]$ are assumed as known and must only be revised
- Function values for $(0^\circ ; 30^\circ ; 45^\circ ; 60^\circ \text{ and } 90^\circ)$ and the corresponding values in the other quadrants are also taken as known
- The emphasis here is on negative angles
- D.1.2.15 Definition of the six trigonometrical ratios for any angle by means of coordinates with respect to a perpendicular system of axes
- D.1.2.16 Deductions of the mutual relations between the trigonometric ratios for any angle
- D.1.2.17 Sin, cos, tan, cosec, sec and cot as functions with a complete description of the distinct domains, ranges and periodicity, the latter as it becomes apparent from the function values for $\theta \pm n.360^\circ$ (characteristics of the last three functions to be deduced from those of the first three respectively by making use of the reciprocal)

- D.1.2.18 Sketch graphs of the curves of the six functions with respect to a set of rectangular axes

Sketch graphs of the sin, cos and tan functions of compound angles (only one deviation allowed e.g. $\sin 2x$ but not $\frac{1}{2} \sin 2x$)

- D.1.2.19 Function values for $90^\circ \pm \theta$; $180^\circ \pm \theta$; $270^\circ \pm \theta$; $360^\circ \pm \theta$; $-\theta$ and $\theta \pm n.360^\circ$ where $n = 1, 2, 3$ expressed in terms of θ

D.1.3 MODULE 3: SUBJECT DIDACTICS

- D.1.3.1 The aims in the syllabuses for Mathematics for Standards 2 to 4

- D.1.3.2 The goals pursued in a lesson

- D.1.3.3 Different types of lessons and teaching methods

Examples of each type; advantages and disadvantages of the different types; how different methods may be used to arouse and retain interest

- D.1.3.4 Elementary teaching aids

The value and use of aids in teaching Mathematics

The use of the chalkboard: lay-out; drawing and construction

- D.1.3.5 Written preparation of lesson

- D.1.3.6 The method of presentation of a judicious choice of themes from the syllabuses for Mathematics Standards 2 to 4 must be studied

- D.1.3.6.1 Numeration system

Egyptian, Roman systems

The Hindu-Arabic numeration system as a decimal system which makes use of place value; number and place value principles in this system; how to make notation and place value meaningful to the primary school pupils

Numeration systems with other bases (base 2; base 5)

- D.1.3.6.2 The basic properties of numbers and the application in operation with special reference to the properties of 0 and 1

D.1.3.6.3 The sets of natural and counting numbers

The number line

The four operations applied to natural numbers;
the relationship signs =, \neq , $>$, $<$

D.1.3.6.4 Factors and multiples

D.1.3.6.5 Vulgar fractions

D.1.3.6.6 Decimal fractions

D.1.3.6.7 Percentages

D.1.3.6.8 Averages

D.1.3.6.9 Ratio and proportions

D.1.3.6.10 Geometric concept (intuitive and practical approach)
with regard to circumference, area, points and lines,
angles, the circle, symmetryD.1.3.6.11 Physical quantities in the SI system for mass, length,
liquid capacityD.1.3.6.12 Number sentences; graphical representation on the number
line**D.1.4 EVALUATION**

D.1.4.1 Candidates are examined in the subject

Provision is made for year and examination marks as
indicated in the schedule below

D.1.4.2 The Examination

D.1.4.2.1 All the questions are compulsory

Paper 1: Algebra (Module 1)	120 marks
Paper 2: Geometry (Module 2)	60 marks
Trigonometry	60 marks

As difficulty could be experienced in setting the question papers so that the total marks for each of the subdivisions come to exactly the prescribed totals, an allowance of 5 marks either way in each of the subdivisions is permissible in Paper 2

D.1.4.4.2 No examination in Subject Didactics in the first year

SUEJECT: MATHEMATICS HIGHER COURSE: DE and HDE YEAR: 1					
MODULE	Exam Paper	Time (hours)	Year Mark	Examination Mark	TOTAL
1. Algebra	1	2	80	120	200
2. Geometry and Trigonometry	2	2	80	120	200
TOTAL			160	140	400

D.2 SYLLABUS: SECOND YEAR

D.2.1 MODULE 1: ALGEBRA

D.2.1.1 Algebraic expressions

D.2.1.1.1 Simplification of advanced algebraic fractions as a direct application of factorization

D.2.1.1.2 Elimination

D.2.1.1.3 Synthetic division

D.2.1.1.4 The remainder and factor theorem with applications

D.2.1.2 Ratio and proportion: K-method

D.2.1.3 Relations and functions: graph, domain, range

D.2.1.3.1 Modulus function: $\{(x;y) \mid y = x + |x|\}$
 $\{(x;y) \mid y = x - |x|\}$
 $\{(x;y) \mid y = \frac{|x|}{x} \text{ or } \frac{x}{|x|}\}$

D.2.1.3.2 Rational function $\{(x;y) \mid y = \frac{ax + b}{cx + d}\}$ where $a; b; c; d \in \mathbb{Z}$
 and c and d not simultaneously zero

$$\frac{ax + b}{cx + d} \begin{matrix} \gg \\ \ll \end{matrix} 0; \text{ asymptotes important}$$

D.2.1.3.3 Polynomial function (only factorizable functions: grouping and factor theorem) of the third degree

D.2.1.3.4 Equations and inequalities of the above-named

D.2.1.4 Indices and logarithms

D.2.1.4.1 Definition of a^n n a natural number with the deduction of the laws

(a) $a^m \cdot a^n = a^{m+n}$

(b) $a^m \div a^n = a^{m-n}$ for $m \geq n$ or $\frac{1}{a^{n-m}}$ for $m < n$

(c) $(ab)^n = a^n b^n$

(d) $(a^m)^n = a^{mn}$

D.2.1.4.2 Extension of the definition of a^n to include all the integers and rational numbers as indices by proving that

(a) $a^0 = 1$ where n is a natural number, $a \in \mathbb{R}$

(b) $a^{-n} = \frac{1}{a^n}$ where n is a natural number, $a \in \mathbb{R}$

(c) $(a^{p/q})^q = a^p$ and hence $a^{p/q} = \sqrt[q]{a^p}$ where p and q are natural numbers $a \in \mathbb{R}$

D.2.1.4.3 Relationship between surds and indices and the corresponding basic characteristics where a and $b > 0$

(a) $\sqrt[n]{a} \cdot \sqrt[n]{b} = \sqrt[n]{ab}$

(b) $\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a}$

(c) $(\sqrt[m]{a})^n = \sqrt[mn]{a^n}$

(d) Rationalization of the denominator

D.2.1.4.4 Logarithms

(a) The exponential function defined by

$y = a^x$, $a > 0$; its graph, shape and position, deductions from graph

(b) The logarithmic function defined by

$y = \log a^x$, $a > 0$ and $a \neq 1$ as the inverse of the exponential function in (a); its characteristics and graph; deductions from the graph

(c) Deduction of basic properties of logarithms (proofs are required)

(d) Change of base (proof required)

(e) Use of (c) and (d) for the simplification of expressions (numerical calculations with pocket calculator)

D.2.1.4.5 Solution of equations

exponential; logarithmic; irrational

D.2.1.5 TRIGONOMETRY

Application of trigonometric functions to angles in a triangle

Deduction of the sine rule, cosine rule and area formula

Solution of triangles

Problems (in two and three dimensions) where these concepts are used

D.2.1.6 Identities

D.2.1.6.1 Simple examples obtained from the mutual relationship between trigonometrical ratios for any angle.

D.2.1.6.2 The identities:

$$\sin^2 \theta + \cos^2 \theta = 1; \quad \sec^2 \theta = 1 + \tan^2 \theta; \quad \operatorname{cosec}^2 \theta = 1 + \cot^2 \theta$$

D.2.1.6.3 Proof of the identity: $\cos(A-B) = \cos A \cos B + \sin A \sin B$

deduction of identities for $\cos(\alpha \pm \beta)$, $\sin(\alpha \pm \beta)$,
 $\cos(90^\circ \pm \theta)$; $\sin 2\theta$; $\cos 2\theta$; $\tan(\alpha \pm \beta)$; $\tan 2\theta$

D.2.1.6.4 Deduction of the identities

$$\sin a \cos b = \frac{1}{2} \{ \sin(a+b) + \sin(a-b) \}$$

$$\cos a \sin b = \frac{1}{2} \{ \sin(a+b) - \sin(a-b) \}$$

$$\cos a \cos b = \frac{1}{2} \{ \cos(a+b) + \cos(a-b) \}$$

$$\sin a \sin b = -\frac{1}{2} \{ \cos(a+b) - \cos(a-b) \}$$

$$\sin a + \sin b = 2 \sin \frac{a+b}{2} \cos \frac{a-b}{2}$$

$$\sin a - \sin b = 2 \cos \frac{a+b}{2} \sin \frac{a-b}{2}$$

$$\cos a + \cos b = 2 \cos \frac{a+b}{2} \cos \frac{a-b}{2}$$

$$\cos a - \cos b = -2 \sin \frac{a+b}{2} \sin \frac{a-b}{2}$$

D.2.1.7 General solutions of

D.2.1.7.1 Simple trigonometrical equations

D.2.1.7.2 Equations of the type: $a \sin x - b \cos x = c$, ($a \neq b$)

D.2.1.8 Graphs of the following functions

$$y = a \sin bx; \quad y = a \cos bx$$

$$y = a + \sin x; \quad y = a + \cos x$$

$$y = a \sin(x + \theta); \quad y = a \cos(x + \theta)$$

Inequalities are also included with the graph

D.2.1.8 ANALYTIC GEOMETRY

The straight line

D.2.1.9.1 Distance formula; midpoint formula

D.2.1.9.2 Slope and gradient of a line
 Parallel and perpendicular lines

D.2.1.9.3 The straight line:

- (a) gradient-point form
- (b) two-point form
- (c) gradient-intercept form
- (d) intercept form
- (e) general form

D.2.1.9.4 The distance from a point to a line

D.2.1.9.5 The distance between two straight lines

Bisector of an angle

D.2.2 MODULE 2: SUBJECT DIDACTICS

- D.2.2.1 The aims in the syllabuses for Mathematics Standards 5 to 7
- D.2.2.2 In-depth study of paragraph D.2.2.3 to D.2.2.6.3 with specific emphasis on preparation and use of teaching aids and utilisation of the textbook
- D.2.2.3 Lesson Structure
- The following aspects may be considered as the basic elements according to which lessons may be structured
- D.2.2.3.1 Lesson detail: School; Standard; Composition of class; Subject; Subsection of Subject; Lesson topic; Date; Time; Duration
- D.2.2.3.2 Lesson notes: General Aims; Specific Aims; Introduction and correlation with previous knowledge; Presentation of new subject matter; Assessment; Application
- D.2.2.3.3 Wherever applicable attention should be given to:
- Didactic form and principles; Method of development; Method of teaching; Learning and teaching methods; Remedial methods; Application; Material for exercises
- The above is the general plan for a lesson when carefully planned lesson notes are required
- D.2.2.4 The aim of the teaching of Mathematics (elementary treatment)
- D.2.2.5 The subject matter of the syllabus
- Study of syllabus standards 5 - 7 with view to:
- D.2.2.5.1 Selection: choice of subject matter for certain groups of pupils (with cognisance of differentiated teaching also)
- D.2.2.5.2 Principles which determine the division and arrangement of units of subject matter according to different standards and groups of pupils
- D.2.2.5.3 Differences between syllabuses for different standards
- D.2.2.6 Scheme of work (Standards 5, 6 and 7)
- Planning of form of scheme of work:
- D.2.2.6.1 Division of work

- D.2.2.6.2 Sequence and arrangement
- D.2.2.6.3 Detailed planning
- quarterly, weekly and lesson units; teaching aids; exercises; examples; test and test planning; revision; differentiated and group teaching
- D.2.2.7 Record of completed work
- D.2.2.8 Preparation
- D.2.2.8.1 Written preparation: form; procedure (daily in advance); preparation of tests; revision lessons; preparation book
- D.2.2.8.2 Preparation with the idea of mastering subject matter and the teaching method by the teacher
- D.2.2.8.3 Preparation of exercises
- D.2.2.8.4 Preparation of and by pupils for a specific lesson or subject matter
- D.2.2.8.5 Planning of pupils' homework; controlling and recording
- D.2.2.9 Evaluation
- D.2.2.9.1 Testing during the course of a lesson
- D.2.2.9.2 Class test (oral, written, practical)
- D.2.2.9.3 Accumulation of year marks
- D.2.2.10 The following themes from the syllabuses for Mathematics Standards 5, 6 and 7 must be studied with the emphasis on the teaching of the subject matter
- The themes must be used to illustrate the concepts mentioned in paragraphs D.2.2.3 to D.2.2.9.3
- D.2.2.10.1 The set of integers: number line; order; the four operations applied to integers
- D.2.2.10.2 Algebra as generalised Arithmetic: formulae; expressions; symbolic language; calculation of values by substitution; the four operations using algebraic expressions
- D.2.2.10.3 Linear equations and inequalities in one variable
- Solution by inspection; graphical representation of the relationship between variable on two number lines at right angles to each other

- D.2.2.10.4 Axioms and theorems (intuitive, experimental and formal deductive approaches)
- D.2.2.10.4.1 If two lines intersect, the sum of any two adjacent angles is equal to 180° and the converse
- D.2.2.10.4.2 If two lines intersect, the vertically opposite angles are equal to each other
- D.2.2.10.4.3 If two parallel lines are intersected by a transversal the corresponding angles are equal the alternate angles are equal the sum of the co-interior angles is equal to 180°
- D.2.2.10.4.4 The converses of 10.4.3
- D.2.2.10.4.5 Triangles: the sum of the angles of a triangle is equal to 180° ; an exterior angle of a triangle is equal to the sum of the interior opposite angles; if two sides of a triangle are equal then the angles opposite those sides are equal and the converse; congruency of triangles
- D.2.2.10.4.6 Quadrilaterals: properties
parallelogram; rectangle; rhombus; square

D.2.3 EVALUATION

- D.2.3.1 Candidates are examined in the subject
- Provision is made for year and examination marks as indicated in the schedule below

SUBJECT: MATHEMATICS	COURSE: HDE (Sec)			YEAR: 2	
Module	Exam, Paper	Time (hours)	Year Mark	Examination Mark	Total
1. Algebra, Trigonometry Analytic Geometry	1	3	70	140	210
2. Subject Didactics	2	$1\frac{1}{2}$	30	60	90
TOTAL			100	200	300

D.2.3.2 The Examination

D.2.3.2.1 Paper 1 (Module 1)

All questions are compulsory

Algebra 75 marks

Trigonometry 40 marks

Analytic Geometry 25 marks

As difficulty may be experienced in setting the question paper so that the total marks for each of the subdivisions come to exactly the prescribed totals, an allowance of 5 marks either way in each of the subdivisions is permissible

D.2.3.2.2 Paper 2 (Module 2)

FIVE questions must be set of which three should be answered

D.3 SYLLABUS: THIRD YEAR

D.3.1 MODULE 1: ALGEBRA

D.3.1.1 Permutations and Combinations

D.3.1.1.1 Definition of each

D.3.1.1.2 Elementary examples to show the difference in meaning

D.3.1.1.3 Meaning of notations: $n!$; ${}^n P_r$; ${}^n C_r$

D.3.1.2 The binomial theorem

D.3.1.2.1 Pascal's triangle as an intuitive approach to the binomial theorem

D.3.1.2.2 The expansions:

$$(1 + x)^n = \sum_{r=0}^n {}^n C_r x^r \quad \text{and} \quad (a+b)^n =$$

$$\sum_{r=0}^n {}^n C_r a^{n-r} b^r; \quad x \in R, \quad n \in N$$

D.3.1.2.3 Elementary applications

D.3.1.2.4 Determination of the coefficients of a term

D.3.1.2.5 Calculation for example of $(1,01)^7$

D.3.1.3 Matrices

D.3.1.3.1 Matrices

D.3.1.3.2 Inverse of a square matrix by Gauss reductions

D.3.1.3.3 Application on linear equations

D.3.1.4 Determinants

D.3.1.4.1 Determinant of 2 x 2 and 3 x 3 matrices

D.3.1.4.2 Minors and co-factors

D.3.1.4.3 Standard characteristics (by means of examples)

D.3.1.4.4 Cramer's rule

D.3.1.4.5 Systems of linear equations restricted to 4 equations; solution by means of echelon form; augmented matrix; conditions for no solution; a unique solution and for an infinite number of solutions

D.3.1.5 ANALYTIC GEOMETRY

D.3.1.5.1 The circle

D.3.1.5.2 The parabola

D.3.1.5.3 The ellipse

D.3.1.5.4 The hyperbola

D.3.2 MODULE 2: INFINITESIMAL CALCULUS

D.3.2.1 Concepts of limits and continuity

D.3.2.1.1 Informal approach by means of graphs of known functions (simple polynomials)

D.3.2.1.2 Left and right limit (intuitive approach)

D.3.2.1.3 Description of neighbourhood of a point (intuitive approach)

D.3.2.1.4 Formal definitions of a limit of a function in terms of neighbourhood; meaning of $\lim f(x) = l$ for

$$x \rightarrow a$$

a finite

a positively infinite

D.3.2.1.5 Definition of continuity of a function at a point and over an interval

D.3.2.1.6 Known continuous functions, inter alia, elementary polynomials; $f(x) = |x|$; $f(x) = \sin x$, $f(x) = \cos x$

D.3.2.1.7 Proof of $\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$

$$\text{Special limit: } \lim_{n \rightarrow \infty} \left(1 + \frac{1}{n}\right)^n = e$$

$$n \rightarrow \infty$$

D.3.2.1.8 Sum, product and quotient theorems for limits (no proofs required)

D.3.2.2 Differential Calculus

D.3.2.2.1 Gradient of a chord

D.3.2.2.2 Gradient of a tangent to a curve

- D.3.2.2.3 Geometric interpretation of a derivative
- D.3.2.2.4 Derivatives from definition of trigonometric functions;
 x^n for n a natural or positive rational number;
 $\log x$; a^x ; e^x ; inverse trigonometric functions
- D.3.2.2.5 Sum; product and quotient theorems for differentiation;
 applications
- D.3.2.2.6 Chain Rule; applications
- D.3.2.2.7 Implicit differentiation; applications
- D.3.2.3 Application of differentiation
- D.3.2.3.1 Extreme value theorem - geometrically approached
- D.3.2.3.2 The value of the first derivative at a maximum or minimum
 point
- D.3.2.3.3 Rol'e's theorem
- D.3.2.3.4 The mean value theorem
- D.3.2.3.5 Application to graphs of functions
- D.3.2.3.6 Higher derivatives (to second order)
- D.3.2.3.7 Second derivative test - factorizable polynomial functions
 (to fourth degree functions)
- D.3.2.3.8 Applications to maxima and minima
- D.3.2.4 TRIGONOMETRY
- Radian measure: deduction of arc length and area;
 prove
- $$\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$$
- D.3.2.5 The inverse trigonometric functions (only introduction);
 graphical representation of arc sin x ; arc cos x ;
 arc tan x ; elementary applications

D.3.3 MODULE 3: SUBJECT DIDACTICS

- D.3.3.1 Nature of Mathematics as a school subject
- D.3.3.2 Mathematics and other subjects
- D.3.3.3 Manifestation of mathematical knowledge
- D.3.3.4 Place of Mathematics in the school curriculum
- D.3.3.4.1 Formative value of Mathematics
- D.3.3.4.2 Vocational value of Mathematics
- D.3.3.4.3 Utility value of Mathematics
- D.3.3.4.4 Mathematics as a service subject for the Natural Sciences,
 Accountancy, Music, Handwork and technical subjects
- D.3.3.4.5 Mathematics in the modern era of computers
- D.3.3.5 The syllabus for Standard 8
 Study of the syllabus for Mathematics with a view to
- D.3.3.5.1 Differences between Higher Grade and Standard Grade
- D.3.3.5.2 Possibilities for enrichment of the syllabus for gifted
 pupils
- D.3.3.6 Scheme of work for Standard 8
 Planning and form of the scheme of work
- D.3.3.6.1 Division of work
- D.3.3.6.2 Sequence and arrangement
- D.3.3.6.3 Detailed planning
- D.3.3.6.4 Different approaches to organising and planning the teaching
 of Mathematics
- D.3.3.7 The pupil and Mathematics
 The inter-relatedness of the following factors and the
 syllabuses taught to pupils in Standards 5, 6, 7 and 8:

maturity; ability; intelligence
 physical abilities and skills
 psychological abilities; insight and memory
 scholastic experiential background
 milieu factors
 attitude; personality of teacher
 temperament and personality of the pupil
 pupil-teacher relationship
 pupils' relationship with other pupils
 facilities at home and at school
 climate and season
 health
 sequence of teaching subject matter
 exercises and drill
 co-ordination with other subjects

- D.3.3.8 The physical conditions and facilities for teaching Mathematics
- D.3.3.8.1 The ideal physical conditions and facilities for the teaching of the subject: accommodation, facilities in the subject or classroom; teaching and learning aids, library, textbooks and exercise books, equipment, material suitable for exercises; stock and storage
- D.3.3.8.2 Procedures for the acquisition of stock, equipment and accommodation
- D.3.3.8.3 Procedures with regard to exhibitions, mathematics competitions and other activities
- D.3.3.8.4 Effective methods of dealing with problems relating to stock, teaching aids, storage and equipment
- D.3.3.8.5 Safety measures
- D.3.3.8.6 Administration with regard to stock and projects
- D.3.3.8.7 Maintenance and care of stock and equipment
- D.3.3.9 Long term undertakings for the teaching of Mathematics (nature; organization, control and evaluation)
- D.3.3.9.1 Individual and group assignments, projects and themes
- D.3.3.9.2 Homework
- D.3.3.9.3 Production, collection, requisition and buying of aids and the systematic and effective use
- D.3.3.10 Evaluation

- D.3.3.10.1 Testing during the course of a lesson
- D.3.3.10.2 Class tests (oral, written and practical)
- D.3.3.10.3 Evaluation of assignments, projects, homework
- D.3.3.10.4 Accumulation of year mark
- D.3.3.10.5 Drafting question paper and memorandum of marking: moderation, duplication, time factor, division and allocation of marks, method of marking and adjudication procedures, checking marks, mark schedules, moderation, adjustment, condonation, promotion schedules, promotion procedures
- D.3.3.11 Extra-curricular activities with regard to Mathematics. Preparation of pupils for competitions and organising of such activities
- D.3.3.12 The teaching methods of the following themes from the syllabus for Mathematics in Standard 8 must be studied
- D.3.3.12.1 Factorization of algebraic expressions
- D.3.3.12.2 Simplification of algebraic expressions (fractions included)
- D.3.3.12.3 Equations and inequalities—solution of linear equations and inequalities in one unknown systems of linear equations quadratic equations by factorization
- D.3.3.12.4 Functions and relations: concept of a function; linear relations; graphical representation of linear relations
- D.3.3.12.5 Quadrilaterals (experimental approach)
- D.3.3.12.6 Formal proofs of theorems with regard to triangles including Pythagoras and quadrilaterals (emphasis to be on the method of presentation)

D.3.4 EVALUATION

- D.3.4.1 Candidates are examined in the subject

D.3.4.1 Provision is made for year and examination marks as indicated in the schedule below

SUBJECT: MATHEMATICS		COURSE: HDE (Sec)		YEAR: 3	
Module	Exam Paper	Time (hours)	Year Mark	Examination mark	Total
1. Algebra, Analytic	1	2	50	90	140
2. Infinitesimal Calculus Trigonometry	2	2	50	90	140
3. Subject Didactics	3	1½	40	80	120
TOTAL			140	260	400

D.3.4.2 The Examination

D.3.4.2.1 Paper 1 (Module 1)

All the questions are compulsory

Algebra 60 marks
Analytic Geometry 30 marks

D.3.4.2.2 Paper 2 (Module 2)

All the questions are compulsory

Infinitesimal calculus 60 marks

Trigonometry 30 marks

As difficulty could be experienced in setting the question papers so that the total marks for each of the subdivisions come to exactly the prescribed totals, an allowance of 5 marks either way in each of the subdivisions is permissible

D.3.4.2.3 Paper 3

(Module 3) (Subject Didactics)

FIVE equivalent questions will be set of which the candidate will be required to answer FOUR

D.4 SYLLABUS: FOURTH YEAR

D.4.1 SECTION A

D.4.1.1 STATISTICS AND ELEMENTARY PROBABILITY THEORY

D.4.1.1.1 Calculation of the arithmetic mean, median and mode of ungrouped data

D.4.1.1.2 Frequency:

1. Tabulated data, frequency distribution, class intervals, interval lengths, class midpoints
2. Calculation of the mode and mean of grouped data from frequency tables
3. Graphical representation of a frequency distribution

D.4.1.1.3 Dispersions (Scatter diagrams)

D.4.1.1.4 The drawing of a representative sample:

Random sampling; Principles of stratification; Systematic sampling; Multi-stage sampling; Area sampling (cluster sampling); Judgement sampling

D.4.1.1.5 Probability:

1. Introduction experiments, results of experiments
2. Intuitive probability (chance)
3. Formal probability; experiments - deterministic and statistical experiments; sample space; events
4. Conditional probability
5. Dependent, independent events
6. Theorems on probability (no proofs required) and simple applications;
 - (a) $P(\emptyset) = 0$
 - (b) $P(A') = 1 - P(A)$
 - (c) If $A \subset B$ the $P(B) \geq P(A)$
 - (d) $P(B \cap A') = P(B) - P(B \cap A)$
 - (e) $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

* 7 Elementary and equiprobable events

* 8 Bayes' rule

9 Probability distributions:

(a) Rectangular; Symmetric binomial; general binomial; Normal

(b) Application of the formulae for mean and standard deviation of the normal distribution

(c) Standardization and use of tables for normal distribution

(Problems should be of an elementary nature)

D.4.1.2 INTRODUCTION TO ELEMENTARY LOGIC

D.4.1.2.1 Propositions

Statements, conjunctions, disjunction, negation (\sim)

Conditional, biconditional statements

Proposition and truth tables

Tautologies and contradictions

Logical equivalence

Logical implication

Logically true and logically equivalent statements

D.4.1.2.2 Quantifiers:

1. Universal quantifier

2. Existential quantifier

3. Negation of propositions which contain quantifiers

D.4.1.2.3 Logical reasoning:

1. Arguments (including what is a proof)

2. Arguments and Venn diagrams

3. Arguments and propositions

4. Arguments and quantifiers

5. Conditional statements and variations

D.4.1.3 VECTORS

D.4.1.3.1 The geometric approach to vectors

D.4.1.3.2 The algebraic approach to vectors, i.e. ordered pairs

D.4.1.3.3 Equality of vectors

D.4.1.3.4 Special vectors

1. The zero vector

2. The unit vector (including i and j vectors)

3. The negative of a vector

D.4.1.3.5 Addition of vectors; geometric representation

D.4.1.3.6 Properties of addition of vectors (proofs not required)

D.4.1.3.7 Scalar multiplication and its properties (proofs not required)

D.4.1.3.8 The inner product of two vectors and the angle between two vectors

D.4.1.3.9 Properties of the inner product

D.4.1.3.10 Division of a line segment AB by P such that:

1. the ratio $AP : AB = k : 1$

2. the ratio $AP : PB = k : \ell$

D.4.1.3.11 The vector equation of a line

D.4.1.3.12 Simple applications to Geometry and Trigonometry

D.4.1.4 COMPLEX NUMBERS

D.4.1.4.1 Cononical form: $a + bi$

D.4.1.4.2 Complex conjugates

D.4.1.4.3 Modulus of a complex number

D.4.1.4.4 Complex numbers as ordered pairs

D.4.1.4.5 Fundamental operations with complex numbers

1. Addition

2. Subtraction

3. Multiplication

4. Divisor

D.4.1.4.6 Argand diagrams

D.4.1.4.7 Vector interpretation of complex numbers

D.4.1.4.8 Polar form of complex numbers:

D.4.1.4.9 De Moivre's theorem:

$$\{r(\cos \theta + i \sin \theta)\}^n = r^n(\cos n\theta + i \sin n\theta)$$

D.4.1.4.10 Roots of complex numbers

D.4.1.4.11 Euler's formula:

$$e^{i\theta} = \cos \theta + i \sin \theta$$

D.4.1.4.12 The n-th roots of unity

D.4.1.5 ROOTS OF THIRD DEGREE POLYNOMIAL EQUATION

D.4.1.5.1 Rational roots

D.4.1.5.2 Irrational roots; variation of sign; Descartes' rule of signs

1. Method of successive linear approximations
2. Horner's method of approximation

D.4.1.5.3 Fundamental theorem of Algebra

D.4.1.6 INFINITE SEQUENCES

D.4.1.6.1 General term of an infinite sequence

D.4.1.6.2 Limit of an infinite sequence

D.4.1.7 INFINITE SERIES

D.4.1.7.1 Convergence and divergence

D.4.1.7.2 Necessary condition for convergence

D.4.1.7.3 Sufficient condition for convergence

D.4.1.7.4 Series with positive terms:

1. Comparison test for convergence
2. Ratio test for convergence

D.4.1.8 PARTIAL FRACTIONS involving at most polynomials of the second degree

D.4.1.9 POLAR CO-ORDINATES:

D.4.1.9.1 The polar co-ordinate system

D.4.1.9.2 Transformations between polar and rectangular co-ordinates

D.4.1.9.3 Curve tracing in polar co-ordinates

D.4.1.9.4 An introduction to spherical trigonometry

D.4.1.10 INVERSE TRIGONOMETRIC FUNCTIONS

D.4.1.10.1 Definitions, notations

D.4.1.10.2 Graphical representations

D.4.1.10.3 Principal values

D.4.1.10.4 General values; applications

D.4.1.10.5 Calculations of function values

D.4.1.11 GEOMETRY

D.4.1.11.1 Tessellations

D.4.1.11.2 Elementary transformations (translation, rotation and reflection)

D.4.1.11.3 Symmetry of figures

D.4.1.11.4 Euler's Polyhedron formula (proof not required)

D.4.2 SECTION B: CALCULUS

D.4.2.1 LIMITS AND CONTINUITY

D.4.2.1.1 Formal definition of a limit of a function:

1. $\lim_{x \rightarrow a} f(x) = l$ if $\forall \epsilon < 0, \exists \delta > 0$ such that

$x \rightarrow a$

$$|f(x) - l| < \epsilon \quad \text{for } 0 < |x - a| < \delta$$

D.4.2.1.1 2. $\lim_{x \rightarrow \infty} f(x) = l$ if $\forall \epsilon > 0$, a number N exist such that

$$|f(x) - l| < \epsilon \text{ for } x \geq N$$

3. Simple applications of 1.1.1 and 1.1.2

D.4.2.1.2 Formal definition of continuity of a function at a point and over an interval:

1. $f(x)$ is continuous in $x = a$ if given $\epsilon > 0$ there exists a $\delta(\epsilon) > 0$ such that $|f(x) - f(a)| < \epsilon$ for $|x - a| < \delta$
2. If $f(x)$ is continuous over the interval $[a; b]$ the $f(x)$ has a minimum and a maximum value within the interval
3. The continuity of $cf(x)$, $f(x) + g(x)$ and $f(x) \cdot g(x)$ if f and g are continuous (no proofs)
4. Tests for continuity using 1.2.1 - 1.2.3

Simple applications

D.4.2.1.3 Indeterminate forms $\frac{0}{0}$, $\frac{\infty}{\infty}$, $\infty - \infty$, $0 \cdot \infty$ and L'Hospital's rule:

$$\lim_{x \rightarrow a} \frac{f(x)}{g(x)} = \frac{f'(a)}{g'(a)} \quad \text{where } f(a) = g(a) = 0$$

$x \rightarrow a$ but $g'(a) \neq 0$

Problems requiring only one application of the rule

D.4.2.2 INTEGRAL CALCULUS

D.4.2.2.1 The concept of area, limit approximation to area; lower upper bounds of area bounded by a curve

D.4.2.2.2 The trapezium rule

D.4.2.2.3 The definite integral, the sign of the integral, properties of the definite integral

D.4.2.2.4 The indefinite integral: properties, constant of integration

D.4.2.2.5 The integral as a limiting value of a sum; equivalence of

$$\lim_{\delta x \rightarrow 0} \sum y \delta x \quad \text{and} \quad \int_a^b y \, dx$$

D.4.2.2.6 Integration as the inverse of differentiation. The process of integration, integrand and integral. Fundamental theorem of Calculus (no proof)

D.4.2.2.7 Integration techniques:

1. Using standard forms
2. Substitution
3. Using elementary trigonometric substitutions
4. Rational algebraic functions
5. Integration by parts (at most two applications)

D.4.2.2.8 Applications of integration:

1. Evaluation of definite integrals
2. Areas of laminae (ellipse included)

D.4.3 SECTION C: SUBJECT DIDACTICS

REMARKS: The sections indicated with a double asterisk (***) will not be examined but should be included in the list of projects for which a year mark is awarded

D.4.3.1 The nature, place and role of Mathematics as a school subject and its relationship to other spheres of life

*** D.4.2 The Mathematics teacher

D.4.2.1 The characteristics of the Mathematics teacher

D.4.2.2 The role of the Mathematics teacher

D.4.2.3 The attitude of the Mathematics teacher towards the subject

*** D.4.3 The Mathematics pupil

D.4.3.1 The social, economic, intellectual and emotional factors influencing the pupil's attitude towards the subject

D.4.3.2 The pupil-teacher and pupil relationships

- D.4.4 Number sense i.e. Man's ability to quantify
- D.4.5 Teaching methods approaches
- D.4.5.1 The deductive-analytical method
- D.4.5.2 The inductive-synthetic method
- D.4.5.3 The scientific method
- D.4.5.4 The lecture method
- D.4.5.5 The textbook method
- D.4.5.6 The role of teaching aids in the above method
- D.4.6 Programmed-teaching
- D.4.7 The history of Mathematics
- D.4.7.1 The history of Algebra
- D.4.7.2 The history of Co-ordinate Geometry
- D.4.7.3 The history of Geometry
- D.4.7.4 The history of Trigonometry
- D.4.7.5 The history of Calculus
- D.4.7.6 The history of Statistics
- D.4.7.7 The history of Vector Algebra
- D.4.7.8 The history of the development of the number system
- D.4.7.9 The history of the development of mechanical aids for calculations
- D.4.7.10 A discussion of the contributions made by the Greeks, Egyptians and Arabs to the development of Mathematics
- D.4.7.11 Biographies of a few renowned Mathematicians e.g. Euclid, Pythagoras, Newton, Napier, Pascal, Euler, Gauss, Brahmagupta
- D.4.8 Teaching methods, aids and approaches to the following topics from the Senior Secondary syllabi
- D.4.8.1 Formal proofs of Geometry theorem
- D.4.8.2 The solution of Geometry riders
- D.4.8.3 The teaching of accurate geometric constructions
- D.4.8.4 The teaching of Co-ordinate Geometry
- D.4.8.5 The introduction of trigonometrical ratios
- D.4.8.6 Methods of teaching factorisation of trinomials
- D.4.8.7 The function concept
- D.4.8.8 The teaching of worded problems in Algebra
- D.4.8.9 The teaching of elementary Calculus
- D.4.9 Differentiation
- D.4.9.1 Differences between Higher Grade and Standard Grade
- D.4.9.2 Differentiation as applied to all aspects of teaching e.g. presentation, assignments, tests and examinations
- D.4.9.3 Differentiation within the same class-group
- D.4.9.4 The slow-learner. Didactic remediation
1. Didactic causes of problems
 2. Didactic diagnosis
 - (a) Fault-analysis
 - (b) Teacher's test
 - (c) Didactic interview
- D.4.10 Schemes of work for the Senior Secondary syllabuses and examiners' reports
- D.4.11 Evaluation: tests and examinations
- Continuation of third year work
- D.4.12 Inspection
- D.4.12.1 Duties of the teacher before, during and after inspection
- D.4.12.2 Authority and duties of the Inspector of Education, Subject Advisor, Principal and Subject Head Functional interrelationship
- * D.4.13 The role of computers in the teaching of Mathematics in the future
- D.4.14 Project study relating to the afore-mentioned themes

D.4.4 EVALUATION

Candidates are examined in this subject and provision is made for class marks and examination marks as indicated in the following schedule:

(Department = D; College = K)

SUBJECT: MATHEMATICS COURSE: HDE(Sec) YEAR: 1V						
Section	Exam Paper	Time (hours)	D/ K	Year Mark	Exam Mark	Total
A Statistics)						
Probability)						
Elementary Logic) (30)						
Vectors)						
Geometry)						
Trigonometry) (30)						
Polar Co-ordinates)						
Algebra) (30)	1	2	D	40	90	130
B Infinitesimal	2	2	D	40	90	130
Calculus						
C Subject Didactics	3	2	K	50	90	140
TOTAL				130	270	400

YEAR MARK

The year marks for SECTION A and SECTION B are accumulated from the marks awarded for examinations and tests. The year mark for Section C is derived from marks awarded for at least 3 projects (out of 30 marks) and for examinations and tests (out of 20 marks)

APPENDIX E

LISTS OF REFERENCE BOOKS AVAILABLE
IN COLLEGE LIBRARIES DURING 1986

1. ANDERSON, R.W. Romping through Mathematics.
2. BEHR, A.L. Teaching the new arithmetic.
3. BELL, F.H. Teaching and learning Mathematics.
4. BISHOP, E. Teaching Mathematics in secondary schools.
5. BOYER, C. The history of Calculus and its conceptual development.
6. BOSCH, M. A guide to the teaching of basic Mathematics.
7. BUTLER, F. The improvement of teaching in secondary schools.
8. BUTLER, WREN and BANKS. The teaching of secondary Mathematics.
9. BURCKHARDT, H. The real world and Mathematics.
10. CHAPMAN, L.R. The process of learning Mathematics.
11. COPELAND, R.W. How children learn Mathematics.
12. COSFORD, Q. Remedial teaching.
13. DIENES, Z.P. An experimental approach; Study of Mathematics learning.
14. DUMINY, P.A. Education 1, 2 and 3.

15. ERASMUS et al. Wiskunde vir onderwysstudente vir die senior primêre kursus.
16. FREEMAN, L. Fun with Geometry.
17. FARMER, D. Getting on with Mathematics.
18. HART, K.M. Childrens' understanding of Mathematics.
19. HILTON, P. Fear no more.
20. HOGBEN, L. Mathematics in the making.
21. HOWARD, F. Teaching Mathematics.
22. JOHNSON, M. Understanding numeration systems.
23. KANE, P. Modern world Mathematics.
24. LAND, F. The language of Mathematics.
25. LIEBECK, P. How children learn Mathematics.
26. MATTHEWS, G. Mathematics through school.
27. MARJORAM, D.T.E. Teaching Mathematics.
28. MARSH, L.G. Children explore Mathematics.
29. NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS. The slow learner in Mathematics.
30. PALING, D. Teaching Mathematics in primary schools.
31. POTTER, G. The teaching of Arithmetic.
32. ROGERS, J. The story of Mathematics.
33. ROWEN, A.J. Mathematics for everyday life.
34. ROUSE BALL, W.W. A short account of the history of Mathematics.
35. SERVAIS, W. Teaching school Mathematics.
36. SCMINKKE, C.W. et al. Teaching the child Mathematics.

37. SCHNUGH, V.E. et al. Method of Mathematics.
38. SCOPES, P.G. Mathematics in secondary schools.
39. SHUMWAY, R.J. Research in Mathematics Education.
40. SKEMP, R.R. The Psychology of learning Mathematics.
41. SMITH, D.E. The History of Mathematics.
42. STOLTZ, D. Low attainers in Mathematics.
43. TURNER, E. Teaching aids for elementary Mathematics.
44. VAN DER ROSS, R.E. The psychology of Arithmetic.
45. VAN STIGT, A. Success in Mathematics.
46. WILEY, J. Contemporary teaching of secondary school Mathematics.
47. WILLIAMS, J.D. Teaching techniques in primary maths.

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