A comparison of the official primary mathematics curriculum in Ghana with the way in which it is implemented by teachers

By

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

To Gladys, Senyo and Selom

ABSTRACT

The official school mathematics curriculum - textbooks, teacher's handbooks, and syllabus - has a powerful influence on classroom practice in a developing country like Ghana, where many teachers with low teaching qualifications hardly ever have access to other sources of information and activity for their teaching. The official mathematics curriculum for Ghanaian primary schools was originally written with the small intellectual elite, who will proceed to secondary and further education, in mind. Concerns have been raised internationally for countries still using such curricula to adjust them, but the Ghanaian official school mathematics curriculum has remained in use in the nation's schools since their introduction in 1975 with no significant revision.

The study, on the one hand, involved an investigation of the extent to which primary teachers in Ghana translate the contents of the official mathematics curriculum into classroom reality. On the other hand, it addressed issues related to the nature, and appropriateness, of the current official primary mathematics curriculum, which was an adaptation of the products of the 'new-math' project spearheaded by the West African Regional Mathematics Programme in the 1970s.

The study used a range of methods for data collection. These include an extensive content and curriculum analysis of the official primary mathematics curriculum materials, and a questionnaire survey of teachers' coverage of the content and teaching methods prescribed by the official curriculum. The questionnaire survey of teachers' coverage of teaching methods involved the observation of teachers in classroom settings. Tape recordings of lessons and instructions from teacher's handbooks were transcribed to provide both qualitative and quantitative data on classroom practice.

The analysis of the curriculum revealed several inefficiencies in the Ghanaian primary mathematics curriculum. Though there was rhetoric in the introduction of the curriculum materials on the use of teaching skills that suggest discovery methods, the analysis indicated that learning/teaching activities that would encourage the use of such teaching skills in the materials were not included. It emerged from the findings that neither what the teachers really taught, nor what the official mathematics curriculum prescribed, was found to be adequate enough to meet the full mathematical needs of pupils. It was found that a very substantial part of the content of the curriculum was taught by the teachers, and both the official curriculum and the teachers, who implement it, emphasised expository teaching methods. It was argued in this light that the low pupils' attainment observed in the subject could not be seen simply as a reflection of the teachers' poor coverage of the curriculum, but as a reflection of inefficiencies within it.

The findings of this study corroborate what is known about curriculum adaptation in school mathematics. It showed that coverage of textbooks does influence the emphasis on topics presented by teachers in their instruction, and also that topics in arithmetic are the most emphasised by both official mathematics curriculum materials and in teachers' actual classroom practice.

TABLE OF CONTENT

PART II

THEORETICAL CONTEXT OF STUDY

PART III

THE METHODS AND RESULTS OF THE STUDY

APPENDICES 325

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

AMP	African Mathematics Programme
CAS	Curriculum Analysis Scheme
CRDD	Curriculum Research and Development Division
CRT	Criterion Referenced Test
GCE	General Certificate of Education
GES	Ghana Education Service
GMOE	Ghana Ministry of Education
GMOEC	Ghana Ministry of Education and Culture
GMOE/PREP	Ghana Ministry of Education - Primary Education Project
GMS	Ghana Mathematics Series (textbook scheme)
GNAT	Ghana National Association of Teachers
JSS	Junior Secondary Schools
NPCIS	National Planning Committee for the Implementation of School Reforms
O-Level	Ordinary Level
WAEC	West African Examinations Council
WARMP	West African Regional Mathematics Programme

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PART I

BACKGROUND AND SETTING OF STUDY

CHAPTER 1

INTRODUCTION

1.1 Background to the study

The complexity of changes occurring in our societies together with discoveries in mathematics and knowledge gained in psychology about how children learn led, in recent decades, to a number of changes in school mathematics curricula in countries throughout the world. In the late 1950s and the 1960s, the desire to improve school mathematics to meet developments in education (considered in Chapter 3) led to the emergence of curriculum development committees or projects and the organisation of several conferences. One such committee, which was inaugurated in Africa as early as 1961, was the African Mathematics Programme (AMP). The AMP spearheaded the major curriculum changes in Africa. The AMP pursued a policy of bringing together African, American and British educators in English speaking African countries to influence mathematics education in Africa. To achieve its objectives, it organised writing workshops in Africa which produced several mathematics textbook schemes (Lockard, 1968). The AMP schemes were tested in a small number of experimental schools mainly in the urban areas of the participating African countries. But the full implementation of the schemes was delayed for over a decade.

In 1970, two regional programmes were established to modify the AMP mathematics schemes for all institutions in the countries participating in the programme (William, 1976). One was the West African Regional Mathematics

Programme (WARMP), which adapted the AMP mathematics schemes for primary, secondary, and teacher training, to the requirements of three participating countries: Ghana, Liberia and Sierra Leone. The mathematics schemes currently being used in Ghana, the *Ghana Mathematics Series* (GMS) textbooks and Teacher's Handbooks (CRDD, 1986a, 1986b), were products of the WARMP. The series was first published between 1975 and 1977 by the Ghana Ministry of Education. Though the GMS scheme was intended to attune the content, and the level and quantity of new technical-language in the original Entebbe materials, to real Ghanaian conditions and to the level of Ghanaian pupils, a survey conducted by the *Curriculum Research and Development Division* (CRDD) of the Ghana Education Service in 1981 (six years after the introduction of the texts into schools) revealed that both pupils and teachers experienced difficulties in the interpretation and use of the materials (Affum, 1984). Based on the feedback from teachers in the 1981 survey, the primary level GMS textbooks and teacher's guides were revised. The revised editions could however not be published until 1986. The revision resulted in two major changes. Firstly, it led to the inclusion of more instructions and explanations in the pupil's books. To illustrate this, extracts of texts from the original (CRDD, 1975) and the revised (CRDD, 1986a) editions are reproduced in Appendix 1.1. Secondly, the topics in the current edition have also been re-arranged to match the order in which they are to be presented as indicated by the new teacher's handbooks. The revision of the texts did not therefore bring about much change in the content, pedagogy and the complexity and quantity of new mathematics language at the various levels of the scheme. The organisation of the content, like the original Entebbe (see Chapter 3) new-math materials, continues to emphasise the structural aspects of mathematics, for example, the commutative, associative and distributive laws. Also the order in which the content is expected to be presented, as in the original texts, continues to receive more attention than the processes involved in their presentation.

Both the AMP and WARMP curriculum materials have been criticised for a number of reasons. Since these reasons are considered in Chapter 3, only a summary will be considered here. These include criticisms that, (a) the contributors were dominated by academics who were not involved in school teaching, rather than school-teachers; (b) the materials were directed primarily at students of high ability and hence the level of, and complexity of, language of the materials developed were too difficult for most students to understand; and finally, (c) the materials put a great deal of emphasis on the structures of mathematics and the use of precise mathematical language (particularly descriptive terminology) making it difficult for teachers to include enough learning tasks that would allow students to learn the use and applications of the subject. But in spite of these criticisms, and the concern raised internationally for developing countries to "reconsider and make adjustments to the traditional mathematics curriculum (a phrase used in this context to embrace the 'new math' curriculum)" (Howson and Wilson, 1986, p.14), the GMS schemes have since remained in the nation's primary schools without an evaluation or a review.

A recent study commissioned by the Ghana Ministry of Education (1992) on '*Factors militating against effective teaching and learning in primary schools*' pointed out that

> in spite of the injection of inputs, (such as textbooks, stationery, and other teaching and learning equipment and materials) into schools, and in spite of the orientation and other in-service courses organised for teachers to improve the teaching and learning processes in schools,
> i) effectiveness of public schools remains low, and
> ii) achievement of public primary schools is low.

In other words, although there is no system of national testing analogous to that in England, the level of pupils' attainment in subjects taught at the primary level, particularly in English and mathematics, has been found to be unacceptably low. The concern about the poor pupil performance in English and mathematics urged the Ministry in 1992 to institute a test, designated "*criterion*[1]*-referenced test*" (CRT), to determine the extent of pupils performance in these subjects. The criteria used in this test were scores that pupils have to attain to be described as having achieved (a) minimum mastery, (b) moderate mastery, and (c) good mastery, of the knowledge and skills specified by the official primary curriculum. The test involved 12,000 pupils and 233 test administrators drawn from all regions across the country. Four content areas were assessed in mathematics. The areas include basic number concepts, number operations, story problems (that is, data handling, commercial arithmetic and use of numbers), and geometry and measurement. The

[1] The term suggests a test in which a pupil's performance on given assessment task is judged against a set of descriptions of knowledge and skills (that is, the criteria defined by a given syllabus). In a criterion referenced test, the term '*criterion*' can refer to a description of the knowledge and skills possessed by the learner, or the score which has to be reached to qualify for a description (Foxman, Ruddock, and Thorpe, 1989). In this test, there was an attempt to use the latter definition but there were no clear descriptions of knowledge and skills (or criteria).

test which comprised 100 items from the four content areas took 140 minutes. A summary of the results of the CRT has been presented in Table1.1.

Table 1. 1 Summary of the results of the criterion-referenced test in mathematics, 1992

Criterion *(or proportion of descriptions of performance mastered)*	Number of pupils meeting criterion out of 12,000	Percentage of pupils meeting criterion
55% or above score	127	1.1
50% or above score	241	2.1
40% or above score	460	8.1

[Source: GMOE, 1994]

The CRT results (Table 1.1) indicate that only 1.1 per cent of the pupils demonstrated mastery over at least 55 per cent of the descriptions of performance that Primary 6 pupils are expected to attain, and only 8.1 per cent of pupils have attained mastery over at least 40 per cent of the content of the primary mathematics curriculum. The results suggest that over 90 per cent of the pupils do not achieve mastery of 40 per cent of the knowledge and skills (specified by the official primary curriculum). The pupils' performance on the four content areas were summarised as

> Pupils scored highest on subsections on mathematical operations, and on geometric shapes. They scored lowest on story problems. More than 50% of the pupils responded correctly to items on adding two digits, subtracting two digits, and on finding the perimeter of a geometric shape. Less than 25% on items related to the number line, percentages, rounding numbers, use of < and > symbols, square roots, multiplying with mixed fractions, and on story problems (GMOE/PREP, 1994)..

The detailed list of concepts and skills on which, according to the CRT report, the pupils' performances were found to be very poor can be seen in Appendix *1.2*.

The educational authorities claim that the poor pupil performance in the subject was due to deficiencies in primary teachers' efficacy in the teaching of mathematics. In identifying the deficiencies, *The National Planning Committee for the Implementation of School Reforms* (NPCISR), stated that

> most teachers
> a) are not confident and competent enough to facilitate the learning of mathematics;
> b) cannot use the prescribed syllabus and official textbooks;
> c) cannot apply the appropriate methods to teach mathematics in the primary schools;
> d) rely on past years' expanded schemes of work to teach pupils; and,
> e) have a negative attitude towards mathematics (GMOE / NPCISR, 1993: p.).

Unaware of the limitations imposed on the curriculum materials by oversights in the adaptation process at the national level, educational administrators claim the poor performance of primary pupils in the subject was due the lack of confidence and competence, on the part of teachers, to teach the content of the materials and use the prescribed methods, to facilitate the learning of mathematics in primary schools. It was argued that teachers rely mainly on past years' expanded schemes of work[2] to teach because they are incapable of using the prescribed syllabus and official textbooks. 'Frame' factors like the physical setting of schools, timetable arrangements, number of lessons in the year, grouping, and class size, are sometimes cited, but are not regarded as crucial as those directly related to the implementation of the curriculum at the classroom level. Other reasons adduced for the poor performance of pupils in the subject include the lack of qualified teachers, lack of in-service training, inadequate supply of textbooks and other instructional materials and the 'loaded' syllabus (Avevor, 1981; and Akyeampong, 1991). But hardly at all are the structure and objectives of the syllabus, and the

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[2] The expanded scheme of work is the name coined for the teacher's lesson plan. The plan which includes seven columns for items like date, topic, objectives, references/teaching materials, core points, expression work and remarks, was recommended by the Ministry to be followed by all teachers.

content of textbooks, considered as factors that are also likely to affect pupils' performance.

In an educational reform programme launched recently (see Chapter 2), efforts to help teachers overcome difficulties in implementing innovations introduced in the subject, in the last two decades, were intensified. More copies of the GMS textbooks have been produced and supplied to schools throughout the country. In-service programmes have been run for teachers. A substantial part of the courses were devoted to the discussion of mathematics textbooks and syllabuses. Thus since the educational reform programme was launched, several policy decisions have been made within the education system at the national level which have led to considerable improvements in several of the above factors. But little consideration has been given at this level to factors directly related to the nature (or appropriateness) of the curriculum itself.

In conclusion, the spur to this study was produced in part by the failure to move the nation's primary mathematics curriculum away from positions adopted between 1960 and the early 1970s, and partly by concerns raised in recent years about what is actually realised in the mathematics curriculum at the primary level. Considering that the mathematical needs of modern Ghanaian society have increased in complexity in the last three decades and that more than 90 per cent of primary school pupils are unable to learn over 50 per cent of the content presented in the official mathematics curriculum, there is the need for a systematic review of the curriculum.

1.2 Conceptualisation of the study: Three aspects of the curriculum

"A school curriculum", according to Hawes (1979), "is very difficult to define". But he contends that whatever the definition is, it concerns "what is planned, provided, selected from the culture for the individual learners in school". The curriculum also includes what the learners actually realise from what is provided. On the basis of what is planned, provided and actually learned, according to Howson and Wilson (1986), the school mathematics curriculum, can be viewed as

i. the intended curriculum: what is prescribed in syllabuses (national and/or examination) and official textbooks;
ii. the implemented curriculum: what teachers teach;
iii. the attained curriculum: what students learn.

This view suggests the mathematics curriculum takes on different embodiments at each of three separate levels in a school system. These levels, according to Travers and Westbury (1989), are the *education system level* where it is planned; the *classroom level* where it is provided (or taught) to learners; and the *student (or pupil) level* where it is seen as what is actually learned. In this study, the *official curriculum* is used to imply the intended curriculum.

Underpinning the conceptualisation of this study is the simple model presented in Figure 1.1 which illustrates the three aspects of the school curriculum and the level of the school system associated with each.

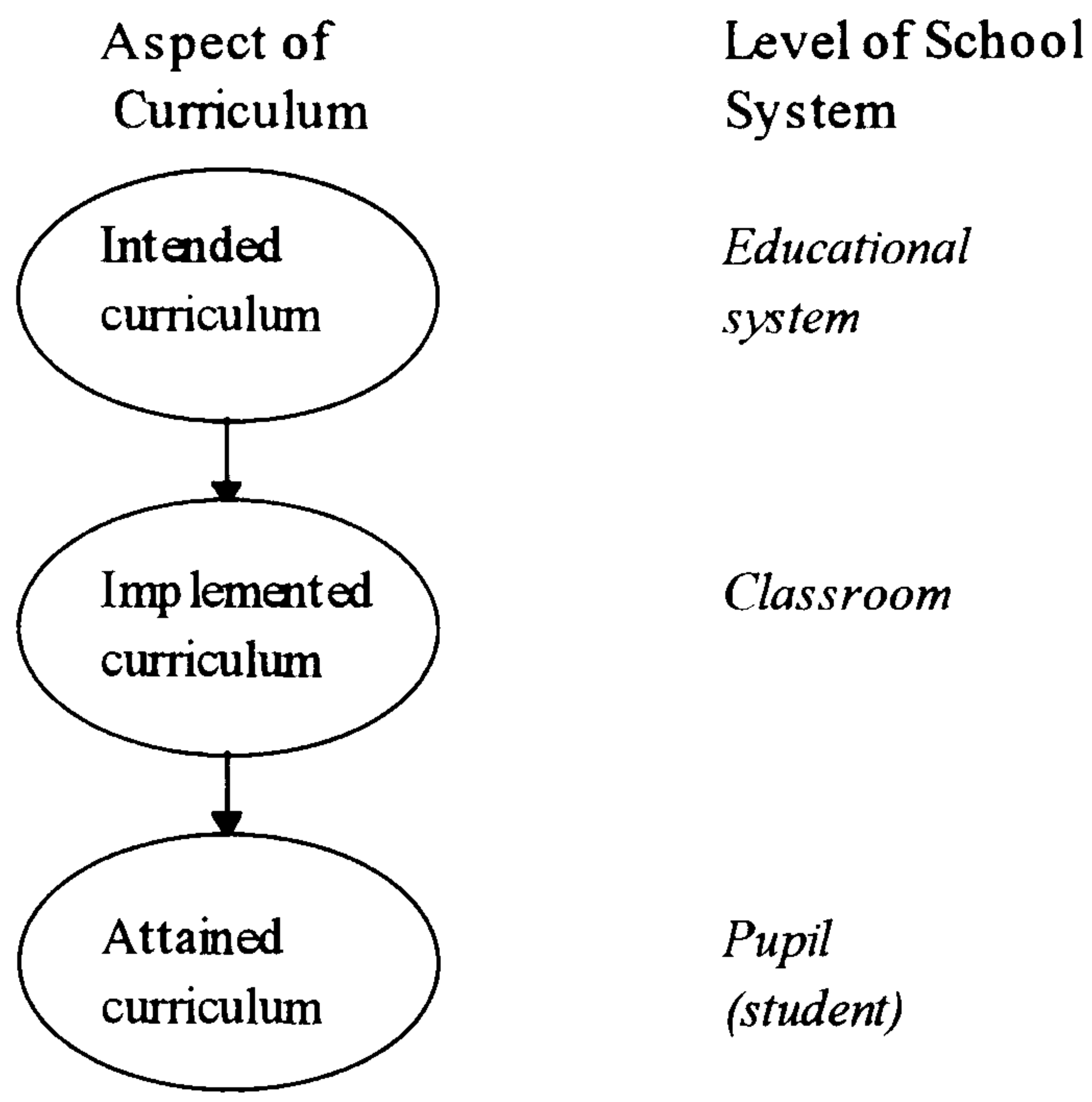

Figure 1. 1 *Three aspects of the curriculum*

At the level of the educational system, two separate sets of intentions were considered in this study for the intended curriculum. The first (designated (a) in Figure 1.2), constitutes all the mathematical needs of pupils which the curriculum is intended to meet. These are expressed by the overall goals and principles governing primary education which are stated in the policy guidelines on primary education and other official documents. The second set of intentions (designated (b) in the figure), is expressed by the objectives, as well as learning and teaching activities, prescribed in the official mathematics curriculum materials. The study examined the correspondence between the two sets of system level intentions to see if there is coherence within the intended curricula as shown in the figure. The implemented curriculum concerns the teacher's classroom practice (designated (c) in the figure) through which the intentions (or content) are translated into reality. The extent to which the content prescribed by the education system is actually taught by the classroom teacher was examined at the classroom level. As can be seen in the figure, what is taught by teachers was compared to what is emphasised at the education system level to examine the extent of correspondence between these levels.

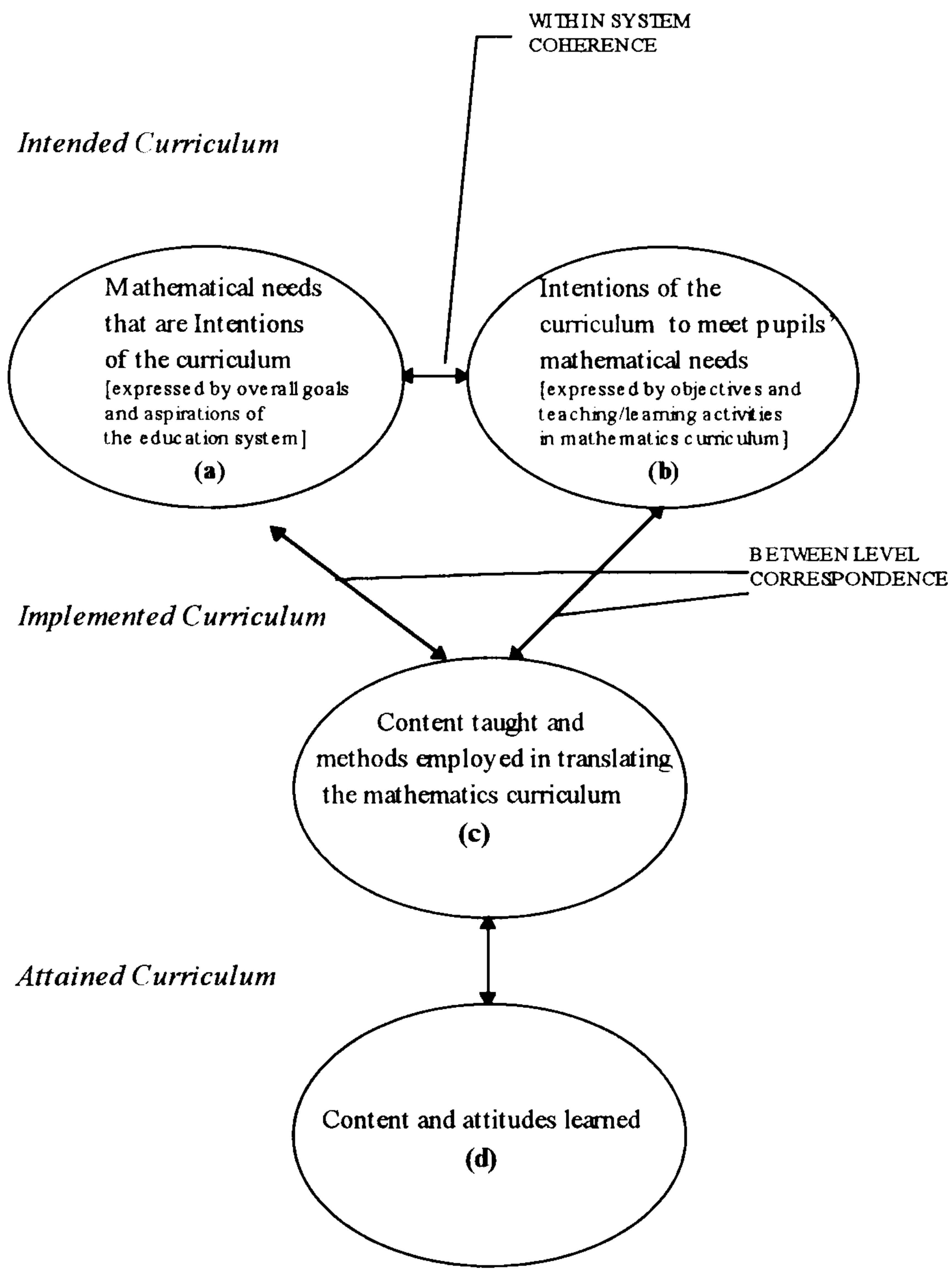

Figure 1. 2 Framework for the study: An illustration of the within system coherence, and between level correspondence examined

The model in Figure 1.2 is based on two assumptions. One concerns the view that, in an efficient school system, there will be substantial coherence (or near absolute conformity) between the system intentions (a) and (b). The other presupposes that the degree of correspondence between the intended and implemented curricula (that is, the correspondence between (b) and (c)) can be used as a measure of teachers' ability to teach content, and employ methods, prescribed by the curriculum. In an efficient school system there will be considerable agreement between the three aspects of the curriculum mentioned in the two assumptions. That is, a substantial part of what is covered in each of the aspects of the curriculum should correspond when considered both within the system level and between the system and school levels.

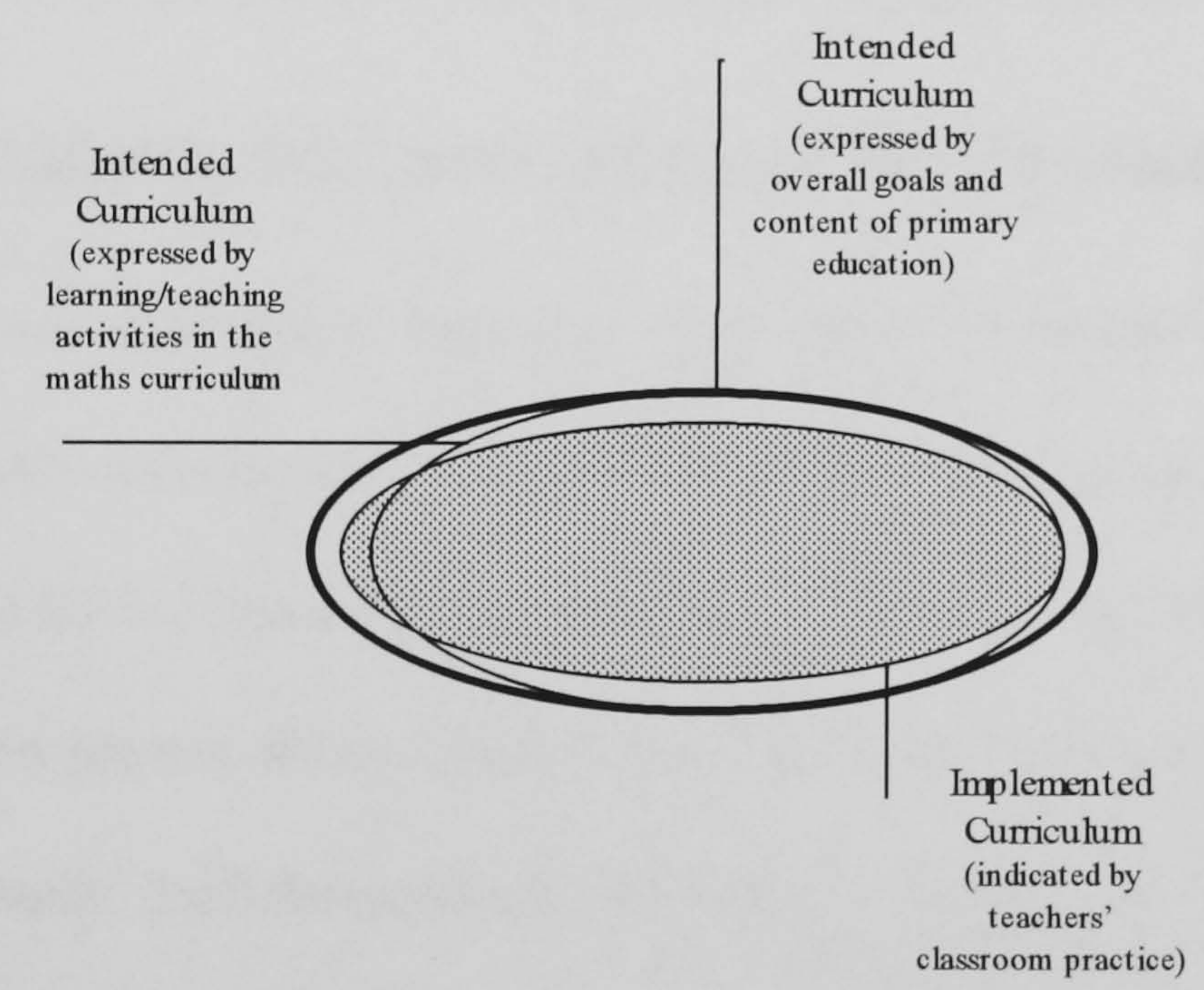

Figure 1. 3 Assumptions underpinning the framework for the study

In other words, as indicated in Figure 1.3, the teaching/learning activities intended for primary mathematics can be presented as lying wholly within (or as a subset) of the overall intentions of the educational system. Furthermore, the teacher's classroom practice through which the intentions of the mathematics curriculum are actually translated into reality, can be presented as lying mainly within (that is, overlapping only slightly) the region representing teaching/learning activities prescribed in the official mathematics curriculum materials at the system level. Large overlaps between the aspects of the curriculum is in this regard an indicator of inefficiencies in the educational system.

The investigation carried out in this study concerns how well the aspects of the curriculum correspond with each other within the system level, and between the system and school levels. It is worth pointing out that though it was not a major concern of the study, the relationship between the curriculum aspects designated (c) and (d) in Figure 1.2, was included in the framework to highlight the area of concern that has led to the study. This is considered in the Section 1.3.

1.3 The problem area and rationale for the study

A lack of correspondence between what teachers actually teach and the content and attitudes actually learned by pupils, or between the curriculum aspects designated (c) and (d) in Figure 1.2, can arise when concepts and skills presented in teachers instruction are not always mastered by the majority of pupils. It can even be the case that pupils' performances are low in topics (or areas of content) given a good deal of emphasis in teachers' classroom instruction. Pupils' attainment also ought to be high in areas of content emphasised in teachers classroom practice or in content areas where the opportunity provided by teachers for pupils to learn is high. In other words, where there is a match between the implemented and attained curricula, more pupils are likely to do well in content areas which are emphasised by teachers than in content areas which are not emphasised.

The CRT results have shown that the majority of pupils are not doing well, or have low attainment, in the subject. With regard to the two situations considered above, the poor pupil performance in Ghanaian schools suggests a lack of correspondence between what teachers teach and the content and attitudes actually learned by pupils. This lack of correspondence raises some pertinent questions which this study is about: Do teachers really teach topics that enable pupils to learn these concepts and skills? Is the content (or topics) emphasised in teachers instruction successfully learned by the majority of pupils? Do the official curriculum requirements demand more from pupils than teachers can provide, given the limited resources available? What makes pupils find these concepts and skills difficult to master?

According to Livingstone (1985), a match or correspondence between what teachers believe they have taught and what their pupils can demonstrate they have learnt, is a measure of "efficiency" of an educational system. The lack of match between what is implemented and what is attained in the curriculum, suggested by the results of the CRT, points to inefficiencies in the primary mathematics curriculum. This lack of match has implications for the appropriateness of the curriculum intended by the education system, and this has led to dissatisfaction among educational authorities in the country about both what is intended, and what teachers implement, in the curriculum. Since the CRT made available some evidence, though not very comprehensive, on pupils' attainment in the subject, it should be possible in this study to compare what teachers believe they have actually taught to what pupils can demonstrate they have learned so as to verify whether there is really a mismatch between the two levels of the curriculum. The aims for this study are therefore to verify whether there is really a lack of correspondence between the implemented and the attained curriculum, identify inefficiencies in the school system that are likely to influence the lack of correspondence between the implemented and the attained curriculum, and to seek reasons for these inefficiencies.

The areas of difficulty identified in the CRT, as mentioned above, involve 'traditional' arithmetic concepts and skills which most teachers and parents have done in their college days, and as a result, are familiar with and are likely to give adequate attention to in their teaching and helping. Therefore if there are any reasons why most pupils find it difficult to master most of the concepts and skills they are expected to learn, these reasons may be related to how successful pupils are in learning what teachers present in their classroom instruction. To claim that the low pupils' attainment in the subject is a reflection of teachers' inability to teach a substantial part of the content of the curriculum, is to assume that the two aspects of the curriculum - content taught and content learned - are not only identical, but are also insufficient (that is, far less than what is expected, or expressed by the official curriculum). This assumption is questionable since what is learned by pupils in the curriculum is influenced not only by teachers but also by such technical factors as the physical setting of schools, timetable arrangements, class size, inadequate supply of textbooks and other instructional materials, and the structure and content of textbooks, to say nothing about pupil capabilities. One aim of the study is therefore to verify if the low pupils' attainment in the subject is really a reflection of teachers' inability to teach a substantial part of the content of the curriculum.

Smylie (1994) pointed out that one way in which curriculum adaptation is evidenced at the classroom level is by differences between formal curriculum requirements (what is intended), and the amount of curriculum actually covered (what is implemented) during classroom teaching. That is, if what teachers believe they have taught (or implemented) is compared to what they are expected to teach (or intended curriculum), the results can be used to describe how well they are able to adapt or teach the curriculum at the classroom level. The measure of what is implemented, is thus necessary in determining the level of adaptation of the curriculum at the classroom level. Another aim of the study, in this respect, is to investigate if there is a match between what teachers believe they have taught (implemented curriculum) and what they are expected to teach (intended curriculum).

It is not unusual in circumstances such as the one currently prevailing in Ghana, for teachers to be blamed for inefficiencies in the educational system. But reviews[3] of the work in several countries, which have used curriculum materials designed by the *African Mathematics Programme* (AMP) and its offspring such as the WARMP, suggest performance of pupils who used the materials was influenced not only by teachers' methods and their unfamiliarity with the new content, but also by the nature of the curriculum materials themselves (Aldrich, 1969; Williams, 1974; Ohuche, 1978; Wilson, 1992). The criticisms made against the AMP and WARMP curriculum materials pose questions about the appropriateness of the curriculum materials currently in use in Ghanaian schools. A third aim of the study

[3] Chapter 3 reviews the literature on innovations in school mathematics in the last three decades.

is therefore to investigate if the low pupil attainment in the subject is a reflection of limitations within the official curriculum itself.

1.4 Summary of the scope of the study

The study involves an analysis of the primary mathematics curriculum in Ghana. It involves, on the one hand, an examination of the intended curriculum to see if its nature can influence pupils' attainment in the subject. On the other hand, it involves investigating if teachers can really use methods, and present content, prescribed in official curriculum materials. To determine how well teachers can use methods and present content prescribed in official curriculum materials, the study involved measuring the extent of *curriculum adaptation* at the classroom level. It was expected that the results of the extent of the adaptation of the curriculum would provide evidence to verify if the low pupils' attainment in the subject is really a reflection of teachers' inability to teach a substantial part of the content of the curriculum. Additionally, the study explored the influence of certain teacher characteristics and organisational factors on teachers' coverage of the subject matter content of the mathematics curriculum.

To determine whether or not the nature of the curriculum materials has any influence on pupils' attainment in the subject, the study involved an *analysis* of the curriculum materials. The analysis was intended to reveal inconsistencies within the curriculum and oversights that occurred in the process of its adaptation at the national level; and show whether the organisational structure and complexity of the curriculum contributes to the poor performance in primary mathematics in the country. Finally, the study considered recommendations that might foster the improvement, and use, of the official primary mathematics curriculum materials, and suggestions for amendments to the official primary mathematics curriculum and materials in the light of what teachers appear to do and not to do.

CHAPTER 2

THE SETTING OF THE STUDY

2.1 Introduction

This chapter provides an outline of the educational system in Ghana. Its purpose is to describe and comment on developments, policies and practices in the educational system which will enable the reader to understand, and appreciate, the value of the questions being investigated in this study. It begins with a brief description of the geographical background of the country. It traces the development of formal education in the country from the time of its independence from colonial rule to the recent educational reform programme which was launched in 1987. A substantial part of the chapter is devoted to the primary education system with particular attention to the following aspects - administration and management, the curriculum and teaching and learning in schools, and the initial and in-service training of primary school teachers. The chapter finally looks at the primary mathematics curriculum in Ghana and examines evidence of poor pupil performance in mathematics.

2.2 Ghana: Geographical background

Ghana is a West African nation formed as an independent state in March 1957 and declared republic in 1960 after a half century of British colonial rule.

Before it attained its independence, the country was called the Gold Coast. According to Cameron and Hurst (1983), the country was the first British colony in sub-Saharan colonial Africa to be granted its independence because of its then economic strength and the presence of a highly educated cadre of its own that was quite capable of assuming power. Ghana is a country located almost centrally on the long southward facing coastline of West Africa that stretches from Dakar in Senegal to the southern portion of the Republic of Cameroon. Ghana covers an area of 239,460 square kilometres (i.e. approximately 92,000 square miles which is almost twice the size of England). It is bounded in the south by the Gulf of Guinea, and in the east, west and north by West African states of Togo, Côte d'Ivoire and Burkina Faso respectively. The country is divided into ten administrative regions, and each region divided into a number of districts. In 1992, there were as many as 85 administrative districts throughout the country. The population of the country at the time it became a republic in 1960 was 6.7 million (Boateng, 1966 p.133). The figures rose sharply to approximately 12.2 million in 1984, and was estimated to be growing at an annual average rate of 3 per cent (Central Bureau of Statistics, Ghana, (1984). On the basis of this annual growth rate the population is expected to reach 23 million in the year 2000[1].

According to Antwi (1992), more than two-thirds of the population, that is approximately 68.7 per cent of the population live in rural areas where subsistence

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[1] Antwi (1992, p3) reported E. Oti Boateng to have indicated this in an open lecture on '*Ghana's Population: Implications for Economic Growth*' delivered at the Thirty-Sixth Annual New Year School, held at the Commonwealth Hall, University of Ghana, Legon, on the 28 December 1984 to 2nd January 1985.

agriculture - farming and fishing - is the predominant economic activity. In spite of its small size, Ghana is ethnically divided into small groups speaking more than 50 indigenous languages or dialects (Adjabeng, 1980). The popular among these languages are Akan, Eʋe, Gä, Nzema, Dagbani, and Hausa (Boateng, 1966 p.10). Most of the languages are spoken by groups of only a few hundred people. The Akan language, however, is becoming more popular because it has the largest number of native speakers and is also used as the medium of communication in big markets all over the country. Although English is the nation's official language (that is, major language of law, government, and education) it is not spoken by the majority of people.

2.3 Brief account of the development of education in Ghana

As in the rest of Africa, Western schooling was introduced into the Gold Coast by missionaries as early as 1765 and was continued throughout the nineteenth century as a philanthropic enterprise of Christian missions (Graham, 1971; Michel, 1988). By 1881, there were 139 schools, of which three were colonial government schools, and the total enrolment estimated at 5,000. In 1882, the colonial government began to take an active part in education, with a board of education nominated to oversee schools inspection and to standardise school management (Antwi, 1992 p.32). Before the 1960s, the system of education that existed in the country emphasised literary skills and prepared pupils largely for "white collar" jobs. The curriculum materials used in schools were replicas of those used in English schools. Success in the colonial educational system was measured by performance in examinations designed for pupils growing up in the colonisers' countries whose experiences and needs were different from pupils growing in the colonies.

By 1950, a total of 300,000 students were enrolled in schools throughout Ghana, with the British colonial government in 1952 encouraging increased attendance by declaring elementary education free of fees. The later part of the 1950s and the first few years of the 1960s marked the period that most African countries gained their independence from foreign domination. At independence, governments were full of optimism and there was a widespread feeling throughout the newly independent states that things were going to change, and for the better, in all spheres of life. The search for new systems and policies of education which would serve as tools for the rapid development of the human resources of the new nations became a major concern of African governments. They sought policies that would transform their educational systems into those that can turn out, in the shortest possible time, completely literate working populations for the development of their economies. The search for relevance in education led to a number of conferences[2] of African ministers of education advocating the replacement of the

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[2] (a) UNESCO (1961), *The Addis Ababa Report on the Development of Education in Africa*. Paris: UNESCO :
(b) J.A. Ponsiuer (ed) (1971) *Educational Innovations in Africa: Policies and Administration* Proceedings of a symposium on Educational Innovations in Africa held at Addis Ababa from 1-10 September, 1971, Institute of Social Studies - The Hague, The Netherlands;
(c) UNESCO (1982), *The Network of Educational Innovation for Development in Africa*. (NEIDA): Progress and Prospects. ED 82/MINEDAF/REF 4, 1982; and
(d) UNESCO (1982), *Specific Aspects of Educational Development in Africa* (Conference of Ministers of Education and those Responsible for Economic Planning in African Member- states organized by Unesco with the cooperation of ECA and OAU) Harare, Zimbabwe, 28 June - 3 July, 1982, ED - 82/MINEDAF/REF 5, 1982.

"inherited" colonial system with alternative forms of education and innovations in school curricula. To achieve these, major educational reforms to ensure universal primary education were initiated resulting in massive increases in primary school enrolment throughout the continent (Fafunwa and Aisiku, 1982). In Ghana, by an act of parliament (the Education Act of 1961), the six-year fee-free Universal Primary Education (UPE) which was established a decade earlier by the 1952 Education Ordinance was extended to cover also the four-year middle school education. That is, UPE was extended to cover a ten-year elementary education.

Though it has been the aspiration of successive governments of Ghana to improve the system of education in the country, changes realised, since independence, in the education system are stronger in quantitative terms than the quality of education being received by pupils in schools. More schools were opened and primary school enrolment rose from 503,000 in 1960 to 967,000 in 1970 (The World Bank, 1988). The rapid rise in school enrolments led to the appointment of a large number of elementary school leavers, referred to as pupil teachers to teach in the hundreds of newly opened schools.

Table 2. 1 *Supply of Trained and Untrained Teachers in Basic Education by Year*

Year	Total teachers	Number trained	Number untrained	Proportion untrained
1959	21,200	14,200	7,000	33%
1969	47,880	22,505	25,375	53%
1979	103,689	59,589	44,100	42%

Table 2.1, which was extracted from three different sources (Forster, 1965; GMOE, 1972; and Ghana Education Service, 1980), indicates how in three recent

decades the proportion of pupil teachers (or untrained teachers) had never fallen below 30 per cent of the teaching force, in spite of the increasing supply of trained teachers. It was not long before the progress of the post-independence educational reforms began to lose momentum. The nation's educational progress was retarded by political instability and economic problems. Politically, the nation has fluctuated between civilian and military governments[3], with the change often brought through military coup. The changes in government often resulted in abandonment of educational plans and changes in educational policies. During the 1970s, the economies of many less developed countries including Ghana were crippled by a marked deterioration in terms of trade of primary products, making prices of agricultural products to drop drastically in spite of rising energy prices. Given that Ghana is predominantly an agricultural country with cocoa as its major export, the crisis left the nation's economy in serious disarray. This development forced governments to make drastic cuts in the nation's educational budgets. A World Bank source reported public expenditure on education to have fallen from 253.0 million dollars in 1975 to 80.9 million dollars by 1983 making the percentage of actual public expenditure on education in the total government expenditure to drop from 21.5 per cent in 1975 to 15.2 per cent in 1983 (The World Bank, 1988 p.138). These made the nation's ability to sustain schools for the growing

[3] Since 1957, Ghana has seen several political regimes. These are Dr Nkrumah's Convention People's Party (CPP), 1957-1966; General Ankrah's National Liberation Council (NLC), 1966-1969; Dr Busia's Progress Party (PP), 1969-1972; Colonel Acheampong's National Redemption Council (NRC), 1971-1979; Fl. Lt. Rawling's Armed Forces Revolutionary Council (AFRC), June-September, 1987; Chairman Rawling's Provisional National Defence Council (PNDC), 1981-1992; President Rawling's National Democratic Congress (NDC) 1992 to date. For further information see Kessey K D (1987), Ghana: Reflections on 30 years' in *West Africa* Vol. 3629, March 30, 1987 pp612-14.

population to diminish, even with substantial financial aid from abroad (Europa, 1982 p.382). Consequently schools received inadequate supplies of equipment, teaching materials and textbooks while class-sizes doubled. Most schools had just a limited number of copies of the official textbooks and had no copies of the teacher's guides and syllabuses. Many classrooms were without furniture (GMOEC, 1988). The rapid increase in enrolment accompanied by a gradual decline in the nation's financial resources resulted in difficulties in the provision of educational facilities and resources, both human and material.

In 1974, a 'new *Structure* and *Content* of education' was approved by government to replace the system of education that had existed since independence. The designers of the new Structure, the Dzobo Committee, advocated the replacement of the existing Middle schools with junior secondary schools (Dzobo *et al*, 1974). By 1978, junior secondary schools had been opened at the various regional and district centres to trial the new system and to serve also as 'lighthouses' for other schools when the programme was fully implemented. But against the background of increasing enrolment accompanied by a gradual decline in the nation's financial resources, the 'new *Structure* and *Content* of education' could not be fully implemented until a decade later.

2.4 The Educational Reform Programme (ERP) and the Structure of the educational system

As rightly noted by Scadding (1989), it was a decade before the educational reforms planned as early as 1974 began to come to fruition. In 1987 the government of Ghana initiated an educational reform programme which was aimed at revitalising the educational system. The reform programme led to the full implementation of the new structure and content of education, which had been proposed a decade earlier, to replace the old system. The reform, which came about as a result of high-level deliberations between the nation's political leaders and prominent educationists, won the support and financial backing of the World Bank and obtained from it what became known as the education sector adjustment credit or EdSAC. In addition to a financial package, the government signed the EdSAC agreement which was to take a period of six years, to carry out the following policy and budget adjustments:

- re-aligning government subsidies of education in more equitable ways;
- encouraging higher quality of basic education for the country's poorest families;
- cutting significantly on unnecessary or inefficient expenditures on student housing; salaries for non-teaching staff, and the old lengthy secondary school system; and
- raising spending on instructional materials including textbooks, exercise books, and in-service training as budget resources are conserved from the above" (Yeboah, 1990).

The agreement enabled the Ghana government to obtain an initial loan of US $34 million from the IBRD and promises of support from bilateral donors including Norway, Great Britain, Switzerland and the Organisation of Petroleum Exporting Countries (OPEC) Fund. With the help of these foreign donors, the current educational reform programme was launched throughout the whole country in 1987. This led to the phasing out of the four-year middle schools which were replaced by three-year junior secondary schools (JSS).

The old system of education prescribed six years of primary school starting at age 6, followed by four years of middle school (see Figure 2.1).

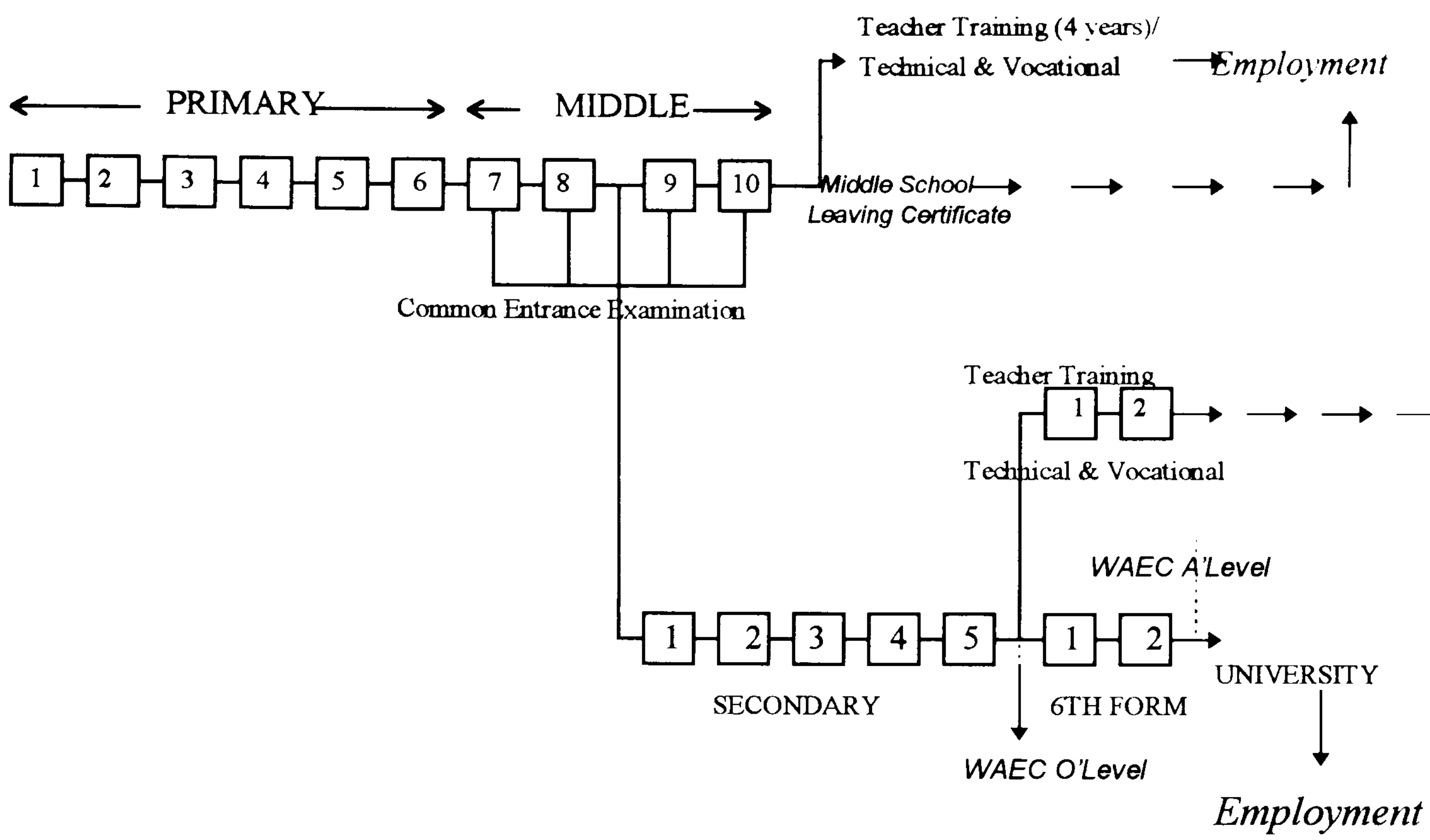

Figure 2. 1 *The old structure of education in Ghana*

The primary school grades are generally referred to as Primary 1, 2, 3, 4, 5, and 6 (or P1, P2, to P6) and the middle school grades were Middle 1, 2, 3, and 4. Though the curriculum of the middle schools was not too different from that offered at the lower level of secondary school, students who completed middle school education were not regarded as having had any form of secondary education. At any time after P6, a pupil could pass on to a secondary school after passing a common entrance examination in English, mathematics, and quantitative and verbal aptitude set by the West African Examinations Council (WAEC). In the tenth grade (that is, Middle 4), there was a separate examination for entrants to initial teacher training colleges; and finally a Middle School Leaving Certificate examination for those terminating their school careers at this stage. In the old system, secondary education took five years; and for those wishing to proceed further to university, there was an additional two-year Sixth Form course. The duration of pre-university education in the old system was therefore often 17 years excluding pre-primary education. This system of education, which was introduced in 1960, remained in force in the country until the recent educational reform initiatives.

The reform had three major objectives. Firstly, it was intended to make a certain level of secondary education comprehensive; that is, make junior secondary level education accessible to the majority, or as many children of school-going age as possible. The introduction of junior secondary education resulted in the shortening of the period of pre-university education from a possible of 17 to 12 years and thereby lowering the cost of schooling and making more funds available to improve quality and access so that the majority of children could get good basic education. The first nine years of schooling, which is free and universal for all children aged normally between 6 and 15 years, was described as *basic education.* It was defined as "the minimum formal education to which every Ghanaian child is entitled as of right, to equip him/her to function effectively in the society" (GMOEC, 1986 p.9) The nine-year basic education, consists of six years primary schooling and three years junior secondary school. Pupils wishing to continue their education after junior secondary school are admitted after the Basic Education Certificate Examination (BECE) to a three-year senior secondary school (SSS) course. At the end of the SSS course, students who qualify proceed to tertiary institutions- university, polytechnic or teacher training college. Figure 2.2 shows the current Structure of Education in Ghana.

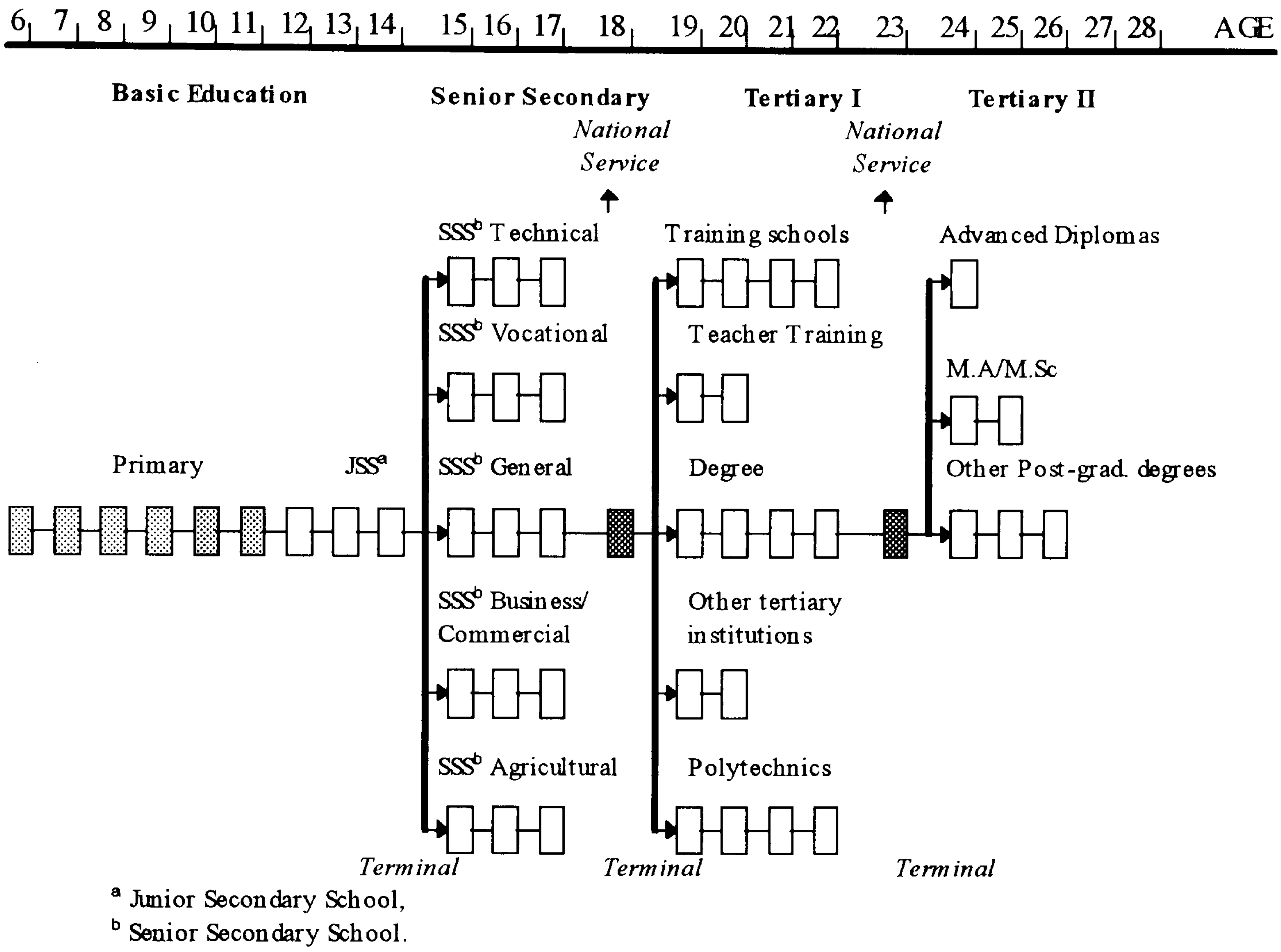

Figure 2. 2 The new structure of education in Ghana

Secondly, the reforms were designed to increase the relevance and efficiency of the educational system by diversifying the curriculum so as to de-emphasise 'elitist' or academic knowledge and also vocationalise it, that is, give it the potential to create employment and assure employability. Thirdly, the reform was to initiate a cost-effective and cost-recovery mechanism in terms of policy and budget adjustments in the nation's educational system. This is to ensure that government subsidies of education are aligned in more equitable ways with the various levels of education; the unnecessary or inefficient expenditures on student housing, salaries for non-teaching staff, and the old lengthy secondary school system were cut down significantly; and spending on instructional materials including textbooks and exercise books was raised.

The reform has brought about a number of changes at all levels of the educational system, but for the purpose of this study I shall only mention those occurring at the Primary level. The change in the structure of education resulted in the establishment of new schools. Over 1,000 new schools have been built in deprived areas; 1,546 classrooms have been re-roofed throughout the country largely through community self-help programmes; 1,983 two bedroom houses were being built for headteachers; and primary enrolment had gone up by over 300 000 bringing the figure to 1,796,000 in 1992 (Ghana People's Daily Graphic, 1994). The duration of the school year has been extended from thirty-three weeks to forty weeks. Intensive in-service courses have been organised for all primary teachers throughout the country as part of the educational reforms. The post of circuit supervisor was created as part of the reform to ensure accountability and effective supervision in schools. Circuit supervisors have since been appointed throughout the country and have been provided with in-service courses to expose them to their new roles. Textbooks and essential curriculum materials have been produced and/or purchased for all subjects of the primary curriculum. For mathematics, more copies of the Ghana Mathematics Series books are now available in all primary schools. Each school has, at least, one copy of the prescribed syllabus. The termination of the competitive selection examination (the Common Entrance Examination), which was used for admission into secondary education was one of the significant curriculum innovations that came with the reforms. This was replaced by the Basic Education Certificate examinations which combines performance in both internal teacher assessment and external examinations. The internal assessment is expected to take a cumulative account of the pupil's performance throughout Basic Education.

Since this study is particularly concerned with work in primary education, the remaining part of this chapter will used to look more closely at aspects of work in primary schools in the country.

2.5 Primary School Education: administration and management

Primary education consists of pre-school (that is, nursery and kindergarten), followed by primary school. It begins with a kindergarten education of 1½ to 2 years, which commences at age 4^+. Primary schools cater for children from about the age of six to twelve or thirteen. Primary education is provided mainly in state owned or assisted schools which are called public schools. A small number of schools are run privately. There are two types of private schools- preparatory and international. The preparatory schools are privately owned and charge tuition fees beyond the means of the average daily-rated worker. The international schools, mostly multi-racial, are run by institutions such as the universities and the armed forces, and public organisations like the Volta River Authority for the children and wards of their employees.

The document '*The Basic Statistics and Planning Parameters for School Education in Ghana*' (GMOEC, 1990 p.1) indicates that in 1989-90, there were 1,703,074 pupils in Ghanaian primary schools and 62,859 primary school teachers, of which 33.6 per cent were untrained. The national pupil/teacher ratio stood at 27.09. In 1989-90, there were 9,831 primary schools in all. The average size of a school was 170 pupils; and average size of classes was 48 pupils (Kraft, 1994 p.41). Almost all classes are about the same age, and, except for certain special cases, all pupils in each class are automatically promoted to the next class. By law, each local authority is required to build, equip, and maintain in its area all public primary and junior secondary schools (GMOE, 1967 p.57). In many schools, the buildings and facilities available are old and have deteriorated over the years due to lack of maintenance. In many classrooms, the furniture available are insufficient for pupils. The furniture in many schools, particularly in rural areas, are in the form of benches and long tables, or the desks in which the writing surface and the seat (usually for two) are joined together. These types of furniture are not suitable for classroom arrangements that allow space for movement, and group-work; and hence, the use of activity methods.

The Ghana Education Service (GES) has overall responsibility for the supervision and co-ordination of all educational activities carried out by public and private schools in the country. It is responsible for devising and issuing teaching programmes to schools, for promoting curriculum development and for overseeing the in-service education of teachers. The GES administers, on behalf of the government, activities concerning the finance of education, supervision, inspection, and the recruitment and mobility of staff. It comprises a number of directorates, including the basic education directorate, and the curriculum, research, and development division (CRDD). The former implements policy matters relating to education at the primary and junior secondary level in both public and private institutions. The CRDD was established in 1967. Some major functions it is expected to carry out include " (a) constant analysis, review and revision of the curriculum and syllabuses; (b) experimentation leading to innovation and development of new curriculum materials; and (c) research into educational problems and curriculum practices" (Badu-Acquah, 1991). But it does very little in respect of the last two functions which involve empirical research work, partly because of lack of funds and partly because it is thought these can be more appropriately done in the universities which are provided with research grants (Menka, 1976).

2.6 Primary school teachers' preparedness to teach mathematics

2.6.1 The initial training of primary school teachers in Ghana

The initial training of primary school teachers in Ghana was done at two levels: the post-middle (or junior-secondary) level; and the post senior-secondary level. Even though programmes offered at both levels led to equivalent qualifications (that is, *Teacher's Certificate 'A'*), the first was a four-year programme while the other was, and still is, a two-year or three-year programme. The four-year college courses were phased out in 1991 and all colleges are now running the 3-year post-secondary programme.

In a recent study, Urevbu (1990) observed a common development that cut across all the curriculum innovations in Africa in the 1960s and 1970s. This was the realisation that many classroom teachers know little of some of the new ideas and techniques which have been put forward in new curriculum materials introduced into schools. Consequently, the development of materials for both pre-service and in-service education programmes to put teachers in readiness for the innovations, was a major aspect of curriculum projects that were carried out throughout the continent. In 1973, a new teacher training mathematics curriculum was put on trial in a few colleges. The selected teacher training colleges (six out of the nineteen that existed at that time) trialed the new mathematics syllabus and the *Teacher Training Volumes* of the GMS textbooks. Following this, new mathematics was first examined in the teacher's final certificate examination conducted by the West African Examination's Council (WAEC) in 1975. Even though GMS materials were introduced into schools throughout the country also in 1975, it was only in 1985, a decade afterwards, that the content of the mathematics curriculum for all other colleges became “modern”. Before all colleges went “modern”, the little that most trainees learnt about ‘new’ or ‘modern’ mathematics in college was encountered mainly during their teaching practice in schools where they were forced to teach the content of the GMS materials.

Owing to the low qualifications possessed by the majority of teachers in primary schools in Ghana before entering teacher training, the training college mathematics courses they pursued laid emphasis on the development of their academic and intellectual capabilities in mathematics. Professional studies courses which dealt with the theoretical and practical aspects of teaching were not given due attention. At the Peki Training college, one of the colleges in the country where the researcher worked as a mathematics tutor between 1981 and 1988, an average of about 8 hours out of the 20 hours timetabled per week were devoted to professional studies courses. The reason for this is simple. The trainee, by the end of his/her training, was expected to have an academic attainment which was equivalent to that of O-level General Certificate of Education (GCE) in the nine or ten different subjects being studied, together with Education and Practical Teaching - the subjects being English Language, Ghanaian Language, Mathematics, General Science, Agricultural Science, Physical Education, Art, Music and Social Studies. Notwithstanding this, not very many of those who had the courage to sit the GCE

Ordinary Level examination in some of the subjects obtained credits or better grades.

Most of the trainees who completed their teacher training during the later part of the 1970s and in the 1980s performed poorly on the final teacher's certificate 'A' methodology examinations in mathematics, even though the methods courses taught in the colleges had been geared more towards the examinations than actual classroom practice (Ammisah, 1987; Institute of Education - University of Cape Coast, 1988). Two papers were usually set for the teachers' final certificate examinations- Mathematics I (the content paper), and Mathematics II (the methods paper). The latter constituted just 29% of the prospective teacher's mathematics score in the final examination. This often led to situations where, as pointed out by Mereku (1987, p.4), "candidates scored zero in the methods paper and yet obtained marks which enabled them to pass well in the examination". The poor performance in the pedagogy aspect of the subject may be attributed firstly to the fact that the mathematics syllabus, for a long time, presented the two aspects of college mathematics (the content, and the methodology) separately. While the content aspect taught, in most colleges, had remained largely traditional until 1985, the orientation of the methodology syllabus, and the methodology paper of the final teacher's certificate "A" examinations, had gradually changed, since 1975, towards the teaching of the GMS curriculum materials. As a result, the two aspects were taught separately even though teacher trainers were advised to integrate the methods with the content. The college tutors continued to use the lecture method, the approach they had used largely in the teaching of the pedagogy of traditional mathematics, even after all colleges had changed to follow the 'modern' mathematics syllabus. Mereku (1986) observed that, in most colleges the tutor in charge of mathematics methods was the only one who took the methodology aspect of the syllabus; and that, since just two forty-minute periods, out of the eight allocated to mathematics, were devoted to methodology work, the performance of teacher trainees in the final certificate 'A' mathematics methodology examinations was not surprisingly low. The lack of integration between the subject matter of mathematics (content) and pedagogical (or methodology) aspects was identified by Amissah (1989) and the *Mathematics Panel of the National Teacher Training Council* - NTTC (1987) as one of the causes for the poor performance. In his opening address to a conference of mathematics tutors of teacher training colleges at Prempeh College in Kumasi in April 1988, the then Director for Teacher Education, noted that

> "In teaching mathematics in the teacher training colleges, there seems to be a dichotomy between the so-called content and methodology. A mathematics tutor teaches the content of the topic and then either half-heartedly treats how to teach it or leaves the methodology aspect to a general methods teacher. As a result, the products of our colleges are not effective in the teaching of the subject at the level they are to operate" [Amissah (1989, p.10)]

The revision of the training college mathematics syllabus in 1986 was the first attempt made by the mathematics subject panel to put the two aspects together into an integrated content and methodology syllabus and as at the time of this study (that is, the 1992 - 1993 academic year), this had undergone two major reviews to reflect the major needs of the colleges.

One conclusion that can be drawn from the nature of the training college mathematics curriculum discussed here is that, at the time of leaving college, many Ghanaian primary school teachers have no secure command of the subject matter to be taught and their competence in teaching primary school pupils mathematics is low.

2.6.2 In-service education provision for primary school teachers

Many teachers after completing their training have not had a workshop, demonstration lesson, or refresher course, organised in the areas where they teach. Even in places where these have been organised, they were not taken seriously by the participants partly because incentives like payment of travel costs, overnight allowances and expenses on course materials were often not provided and also because several of such courses did not count towards the upgrading or promotion of the teacher (Obeng-Mensah, 1972; Dameh, 1983). The few of the primary teachers who achieved some development while in service were the ambitious and intellectually capable ones who pursued academic studies. Through private study of academic subjects, these teachers were able to upgrade their general educational qualifications (i.e. obtain General Certificate of Education - ordinary and advanced levels) and entered Universities and Advanced (or University) Colleges of Education. But these teachers did not come back to the primary schools after obtaining their diplomas or degrees mainly because their further education courses were not tailored to the needs of pupils at this level. Instead most of them preferred to take up more prestigious teaching appointments in secondary schools and

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training colleges or were posted there by the Ministry of Education with the explanation that their services were most needed at these levels.

In Ghana there is the tendency for many people to associate good teaching performance with high academic attainment. Many also think that the higher one's academic qualification the better one can teach. Recently, all teachers whose entry qualification into college was O-Level GCE have, in this light, been sent to teach in junior secondary schools while those whose entry qualification was a junior secondary or middle school certificate have been brought to the primary level. Graduates and Diploma holders teach in the senior secondary and training college levels. The few teachers with O-Level GCE qualifications left in the primary schools are made to teach in the upper classes (that is, Primary 5 and 6). The primary schools therefore lack experienced teachers who are academically ambitious and enthusiastic about their professional development and that of their colleagues.

The Ghana Education Service (GES) was able to sustain its support for teachers to attend mainly two different types of in-service courses in the last two decades. One is the 'prescribe' and 'promotion' courses organised jointly by the GES itself and the *Ghana National Association of Teachers*[4] (GNAT) for serving teachers due for promotion to the ranks of 'Assistant Superintendent' or 'Superintendent'[5]; and the other is the conferences and workshops organised by

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[4] For further information on in-service courses organised by the teachers' only professional association in Ghana, see Asiedu-Akrofi (1982, 1983).

[5] After a two-year probation period a Certificate 'A' teacher obtains a qualified teacher's status. When (s)he does another two years after this (s)he qualifies to attend a 10-day prescribe course. This serves as a preparation for the promotion course which follows the year after. After the successful completion of both

subject associations like the *Mathematical Association of Ghana* (MAG) and the *Ghana Association of Science Teachers* (GAST). In the Winneba district, between 1988 and 1992, the promotion and prescribe courses affected roughly an average of 4 per cent of primary school teachers each year, while workshops organised by subject associations affected only about 1 per cent of the teachers.

Besides, the Schools have no libraries. In addition to the textbooks and the corresponding teacher's handbooks, and their old college notebooks, the teachers hardly have any professional materials (journals, newsletters, periodicals and magazines) to read. There is therefore very little chance for these teachers to improve their general education and professional qualifications.

Against this background, not much provision was made for teachers, in terms of in-service work, during the change-over to the teaching of new mathematics which occurred in the late 1970s with the introduction of the GMS textbooks. Intensive in-service courses, which lasted for a week, were organised throughout the country to help the teachers to understand the aims, content and methods of the new mathematics during the first term of 1975-76 school year. By this time only the pupils' textbooks of the new mathematics scheme were in schools. The teachers' guides were not then ready. Due to limited time and insufficient financial resources, all that the course co-ordinator could do at the one I attended was to dictate for us to copy volumes of materials that were later discovered to be notes in the teachers' handbooks.

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courses the qualified teacher earns his/her first promotion which is the rank of an 'Assistant Superindendent'. (S)he qualifies for the next rank which is superintendent in another five years after (s)he has gone through the prescribe and promotion courses at that level.

The fact that teachers received little with regard to in-service education before the educational reforms, is further supported by a Ministry document, which outlined the need for the in-service course on the teaching of science and mathematics for Primary 6 teachers, issued by the *National Planning Committee for the Implementation of School Reforms* (NPCISR) in 1991. The document indicated that

> "until the late 1970s primary science and mathematics methods were not key components of the programmes for initial teacher training colleges. Hence many teachers operating at the primary level did not get the opportunity to develop desirable attitudes, interests, competence and confidence for facilitating effective learning of science and mathematics for the primary school child" (GMOE / NPCISR, 1991: p.).

The *Report of the Commission on Basic Education*, which was presented to the government in 1986, also indicated that "in-service teacher education has been part of the educational system for some time but it is obvious that it does not affect the majority of classroom teachers". The two pieces of evidence provided here show that most Ghanaian primary school teachers did not receive any further education and professional support while in service until only recently in spite of their poor mathematical background.

In the light of the poor in-service provision, the document *'In-service Training Programme for Teachers under the Educational Reforms in Ghana'*, directed at making teachers understand the aims and aspirations of the reforms, and at updating teachers' knowledge-base in the various subjects of the curriculum, was issued by the Ministry of Education in 1989. It stated that

> each programme for in-service training should be aimed specifically at improving the quality of education at Basic Education level through:
>
> - developing more creative and innovative approaches to teaching;

- encouraging the use of locally available materials in teaching;
- updating the knowledge base and reading skills of teachers;
- enhancing motivation of teachers" (Ghana Ministry of Education and Culture, 1989 : 2).

To achieve these aims a number of in-service training activities have been organised throughout the country since 1987. More than 90 per cent of the courses held were co-ordinated from the Ministry of Education through the *National Planning Committee for the Implementation of School Reforms* (NPCISR). By 1992, the NPCISR had organized twenty-five courses for teachers at the various levels of pre-university education in the country - primary, junior secondary, senior-secondary/teacher-training. 30 per cent of these courses were related to work at the primary level. Table 2.2 provides a picture of in-service activities under the auspices of the NPCISR which were directly related to primary education. By September 1993, twenty-seven courses had been organised and only two (or 7 per cent) of these had directly concerned the teaching of primary mathematics.

Table 2. 2 In-service Courses Organised for Primary School Teachers Under the Education Reform Programme from 1987 to 1992

Date	Course	Number of participants
25 May - 6th June 1987	Course for Training of Teachers for the J.S.S.	10,885
August. 29 - September 4, 1988	Orientation Course for Primary School Heads	5,511
April 17 - May 7, 1990	In-Service Training Course on Continuous Assessment for Primary School Teachers	47,000
August 27 - September 16, 1990	In-Service Training Course on the teaching of Reading Skills for Primary 1 & 6 teachers	19,427
July 6 - 16, 1991	In-service course on the Teaching of Science and Mathematics for Primary 6 teachers.	5,680
May 11 - 26, 1992	In-Service Training Course on the Teaching of life skills and Vocational Skills for Lower Primary teachers	*
October, 1992	In-Service Training Course on the Teaching of English for Primary 4 teachers.	*

[Source: In-service Courses File - Deputy Director General's Office, GES Head Office Accra.
* Figures for 1992 were not ready at the time of interview].

In addition to the reform related in-service courses co-ordinated by the NPCISR, the Ghana National Association of Teachers (GNAT) in response to recent criticisms about teachers' classroom practices, launched a campaign to improve the academic competence of the bulk of school teachers without O'level GCE qualifications. With the co-peration of the GES, the GNAT set up in all regional capitals in the country, *'GCE O'level Centres'*, presumably because of the Ghanaian mentality that higher academic qualifications lead to better teaching performances. The centres, which were started in 1990, provide revision or preparatory courses for O'level GCE examinations in all school subjects. Teachers with no O'level GCE qualifications are encouraged to pay from their own resources to take the courses which are organised after school hours. The courses have since spread to a number district centres. A report in the newsletter of the GNAT, *'The Teacher'*, indicated that the work of the centres are yielding good results and that most of the teachers who took advantage of the centres "were able to obtain either distinction, first or second divisions" (*sic*) (The Ghana National Association of Teachers, 1992).

2.7 The Primary Curriculum

All primary schools are required to work to nationally prescribed teaching programmes. The programmes, which are statutory, are contained in syllabuses. They are intended to be prescriptive in schools throughout the country. That is, they include detailed prescriptions for what is required to be taught in each year. To ensure the programmes provide the basis of the child's basic, and further, education, the following were stated in the Policy Guidelines of the educational reforms as the overall goals of Ghanaian primary schools:

i. Numeracy and literacy, i.e. the ability to count, use numbers, read, write and communicate effectively.
ii. Laying the foundation for inquiry and creativity.
iii. Development of sound moral attitudes and a healthy appreciation of our cultural heritage and identity.
iv. Development of the ability to adapt constructively to a changing environment.
v. Laying the foundation for the development of manipulative and life skills that will prepare the individual people to function effectively to his own advantage as well as that of his community.
vi. Inculcating good citizenship education as a basis for participation in national development. (GMOEC, 1988 p.4)

The goals are directed towards the development of the pupils' intellectual or cognitive capabilities, and their affective qualities.. The first two goals concern the development of numeracy as well as inquiry and creativity skills in pupils.. Numeracy is defined as the ability to read, write and communicate effectively using mathematics (or numerical, and spatial, concepts). The remaining goals concern the development of affective qualities (that is, appropriate attitudes, values, dispositions and sentiments). The goals are expected to form the basis of children's learning experiences in all classes throughout primary education in both public and private schools. Teaching and learning materials intended for this level will therefore normally be expected to allow teachers to translate these goals into everyday curriculum terms. The above goals, according to the Policy Guidelines, have been incorporated into a revised national curriculum comprising nine subjects for all primary schools (GMOEC, 1988 p.5). These include mathematics, science, social studies, cultural studies, Ghanaian language, English language, agriculture, life skills, and physical education.

Pupils attend school for four and a half hours each day including breaks. Schools normally[6] begin at 8.00 a.m. and end at 12.30 p.m. each day, from Monday to Friday for 40 weeks. The number of school hours per year works out to about 800 (Kraft, 1994). The minimum length of time to spend on each subject each week is suggested in the syllabuses.

Table 2. 3 Periods per week indicated by the Timetable as allocated to each class for the Primary School subjects

Curriculum Content	Average number of 30-minute periods per week allocated to each class	Percentage of instructional time devoted to subject	
		GHANA	Countries* with low GNP per capita
Languages		*25.7*	*37*
Ghanaian	4	10.3	
English	6	15.4	
Mathematics		*15.4*	*18*
Mathematics	6	15.4	
Science		*10.3*	*7*
Science	4	10.3	
Social/cultural Studies		*28.2*	*29*
Social Studies	4	10.3	13
Cultural studies (Music & Art)	5	12.8	9
Physical Education	2	5.1	7
Vocational Subjects		*20.4*	*6*
Agriculture	3	7.6	
Life Skills	5	12.8	
Other			*3*

[*Source: Lookheed and Verspoor, 1990]

The Basic Education directorate of the GES has issued to schools what it describes as a 'Suggested Timetable' to guide work in the teaching of the primary subjects.

[6] There are a few schools, mostly in urban centres, running the shift system which operate slightly different times. The morning shift in such cases is from 7.00 am to 12.00 noon, and the afternoon shift is from 12.15 pm to 5.00 pm.

A copy of the timetable can be seen in Appendix 2.1. The number of 30-minute periods per week allocated to the subjects by the timetable, which can be seen in Table 2.1, indicate the curriculum's emphasises on the teaching of language and mathematics.

The timetable devotes 10.3 and 15.4 per cent of the school time to the teaching of the Ghanaian and English languages, respectively; and 15.4 per cent to the teaching of mathematics. Nevertheless, these figures are relatively low when compared to the time devoted to the subjects in several other developing countries whose GNP per capita is low (see Table 2.1). Most other nations have closer to 40 per cent of the teaching time devoted to the national language and 20 per cent to mathematics (Lockheed and Verspoor, 1990). It is important to note here that English is not the native language of children growing in Ghana, but the curriculum for the early years gives it more emphasis than it gives to the local Ghanaian languages. The government's policy on language teaching is that

> the local language shall be the medium of instruction for the first three years of primary school. English shall be learnt as subject from the first year at school and shall gradually become the medium of instruction from the fourth year" (GMOEC, 1988 p6).

However, provision made in the curriculum for pupils to learn the mechanics of reading and writing in their local Ghanaian language, which is a necessary prerequisite for introducing pupils to a foreign language, is relatively low. Besides, the curriculum provides no guidelines as to how the teacher can change gradually from the use of the Ghanaian language to the foreign language.

In teacher's classroom practice, there is great emphasis on the use of the official syllabuses, textbooks and teacher's handbooks, which are the only curriculum materials available to teachers. Work in classes is to follow the textbooks closely. There are however not enough textbooks to go round all pupils in schools. Recent studies on the availability of textbooks in mathematics, English and science in the schools have shown that there is for every 5 pupils an average of 3 textbooks (Cooper, 1993; Yakubu, 1993). Though the teacher's handbooks were found to contain some good ideas and generally aligned with the textbooks and syllabuses, Kraft (1994) found that only 1 in 10 teachers had ready access to them in their instruction. The level of language used in the handbooks, according to Martin and Donkor (1994), is generally above that of the teachers. Most classes are without displays partly because the resources needed to make them are not available in schools, and partly because most school buildings are without locks, and therefore, are unsafe to leave displays on walls.

In all the subjects, the learning and teaching activities presented in the official syllabuses supported by the textbooks tend to favour an expository approach. But general guidelines on the delivery of the curriculum found in policy documents emphasise rather an investigational or activity approach. Teaching in the schools is to be directed towards activities that will encourage "inquiry, creativity, and manipulative and manual skills" (GMOEC, 1988 p. 6). *The Report of the Education Commission on Basic Education* recommended that teaching should not consist of always talking to a class as a whole, giving everybody the same homework, putting questions to individual pupils and administering tests, but also encouraging pupils to give of their best through constant dialogue between teacher and pupils (GMOEC, 1986 p.26).

The educational reforms brought about new arrangements for assessment and record keeping. Progress along primary education is based on continuous and guidance-oriented assessment by teachers and headteachers. The primary teacher's responsibilities in assessing of pupils' performance and progress have been extended from merely giving pupils one-shot tests and examinations at the end of each term to cover the use of informal assessments. These include observation of pupils' personal and affective qualities (that is, appropriate attitudes, values, dispositions and sentiments) and their participation in class; recording and keeping records of pupils' performances in class exercises and projects; and noting significant changes in the pupils' behaviour. Although the teacher completes standardised record-keeping booklets for each child, there are no clear indications as to what use such results are to be put. To ensure they work efficiently and have enough assignments or exercises to enter for pupils continuous assessment records, teachers are required to meet quotas in work output. In certain districts, Directors of Education have issued circulars which require teachers to set and mark a minimum number of subjects per week per subject. In the Dodowa District for instance, Mereku (1992) noted that "the minimum number of exercises per subject for Primary 5 each week (required by the directive), were given as: English - 3; Mathematics - 3; Ghanaian language -3; and each remaining subject - 1".

There are complaints that the new assessment scheme had increased the teacher's workload tremendously (Owusu-Hemeng, 1992), but there is no evidence of what aspects of the curriculum to omit, or to treat as relatively superficial. Many primary schools are not finding it easy to implement the programmes of study, even with the recent increase in efforts to provide teachers with in-service education. This observation is even more true if one considers that the primary teacher is expected to meet the above quotas for nine subjects and complete the assessment plans and booklets for an average of about thirty to fifty pupils in his or her class.

2.8 The Primary Mathematics Curriculum

In the colonial educational system in Ghana, the form of mathematics included in the curriculum at the primary level was arithmetic. The traditional school mathematics taught largely involved mechanical number facts and tables of measurements with little or no applications. Through excessive use of the cane, which was an acceptable negative motivational technique in those days, pupils were *brought* to know the tables of numbers and the tables of measurements, and to solve problems of a practical nature in measuring, commerce, and so on. The word "brought" is used here because the teachers' methods forced pupils to use repetitive and rote learning techniques. In the account that follows, Gyang (1979) a leading mathematical educationist in Ghana, shows clearly how punishment, force and fear were prominent features of mathematics teaching in his own primary school days in the late 1950s.

> "The cane was used indiscriminately so that many of the pupils did not like mathematics and developed true hatred for it. .....
>
> Problems in arithmetic were read out by the teacher, usually only once through, and we were expected to put down only the answer. There were usually ten questions and there was trouble for any one who had any of them wrong. After that we used to line up to recite some tables learnt and to have some oral drills in arithmetic. We actually behaved like parrots and the teacher had his cane always by him ready to beat anyone who had anything wrong. ......
>
> I can still remember a number of my classmates who ended their schooling prematurely just because they could not cope with the mathematics that was taught" (Gyang, 1979 p.23).

Such was the mathematics curriculum that most teachers have experienced in their own school days. Hence before the major mathematics curriculum innovations[7] of the 1960s were launched in Africa, there was already the desire for change. The need to change the traditional school mathematics curriculum, which largely involved mechanical number facts and tables, was urged also by the realisation of the enormous gaps which were opening between the demands of a computer-based technology and the realities of a curriculum designed in the nineteenth century to serve a nation of shopkeepers (Hawes 1979 p.34).

Efforts to change the subject from arithmetic to mathematics at the primary school level increased in the last half of the 1960s. In 1972, '*New Mathematics for Primary Schools* (NMPS)', a new mathematics scheme, which was intended to make "the learning of mathematics by Ghanaian children more interesting and more meaningful to them" (Lockard, 1972, p.9), was officially introduced into primary schools in the country. In 1975, the textbooks were replaced with the scheme

[7] The curriculum innovations of the 1960s are considered in Chapter 2.

which is still being used in schools today, the '*Ghana Mathematics Series*' (GMS). The GMS scheme, whose design is based on similar teaching philosophies and models as what was described as "new mathematics" (Howson, Keitel, and Kilpatrick, 1981), has since 1975 remained the sole mathematics scheme used, as a matter of policy, in the nation's public schools. The introduction of the GMS scheme brought several new topics as well as terms into the subject at the primary level. Examples of the new topics are number bases, sets of numbers, vectors, clock arithmetic, points in a number plane, and chance; and some of the new terms are addend, commutative, distributive, place value, ray, intersection, line segment, mode, rational numbers, integers, to mention only a few.

The *Ghana Mathematics Series* (GMS) textbooks (CRDD, 1986a) and *Teacher's Handbooks* (CRDD, 1986b), and the *Mathematics Syllabus for Primary Schools* (CRDD, 1988) are the official documents that contain descriptions of the intended curriculum. The intended curriculum, as defined in Chapter 1, refers to the formal or official curriculum requirements. The documents provide prescriptions about what mathematics is to be taught, and how it is to be taught throughout the nation's primary schools. These materials constitute the major official curriculum materials that guide Ghanaian teachers in their selection of topics and preparation of lesson notes. There are no puzzle books and other supplementary books. Besides, all previous mathematics schemes were withdrawn as GMS was introduced.

The GMS textbooks scheme was a product of the *West African Regional Mathematics Programs* (WARMP).[8] The series include Pupil's Books and Teacher's Handbooks for the six primary classes, P1 to P6, and were published between 1975 and 1977 by the Ghana Ministry of Education. Mathematics teachers from universities, teacher training colleges, and curriculum development departments based in the Ministries of Education of countries involved in the project - Ghana, Liberia and Sierra Leone- participated in the adaptation of the scheme. The members of the team involved in the adaptation were mainly mathematics teachers who were working at levels higher than the primary schools. Many had never had any primary school teaching experience at all. Like the original Entebbe materials which were adapted, the products of the WARMP, including the GMS scheme, have been criticised because the contributors were dominated by academicians rather than school-teachers.

Under the auspices of the CRDD, the current syllabus was prepared and published in 1988 by a panel of mathematics teachers comprising the experts who reviewed the GMS textbooks in 1986 and a representative of the Mathematical Association of Ghana. The syllabus is a revision of the previous primary mathematics syllabus (CRDD, 1978) which remained in schools for a decade. The syllabus is aimed at aligning the content and pedagogy of primary mathematics with the new approaches and additional topics that came with the GMS schemes. It contains lists of topics and activities that pupils are expected to be provided with by

[8] See Chpater 3

teachers, objectives expected to be attained by pupils after encountering each topic or activity, and brief notes on the activities. The 1988 revision of the syllabus did not add to, or subtract from, the content, but resulted in a complete reorganisation of the contents into what is described as a '*teaching syllabus*'. As a teaching syllabus, it presents the topics and activities in the order in which they should be taught and groups these into the years that they are to be taught. It however makes no attempt to break into terms the work of each year, as in the case of its predecessor.

The syllabus has two main sections. These are the part with the introduction and the part with the programme of study or content. The introduction includes the objectives of the curriculum, a summary of the content, the teaching methods and guidelines for evaluating pupils learning. The programme of study, constitutes about 95% of the document and comprises teaching units arranged in an order that

Table 2. 4 *Format for programmes of study presented in the mathematics Syllabus*

OBJECTIVES	TOPICS	ACTIVITIES/NOTES
Pupils will be able to: (i) form sets and subsets (ii) compare and order sets (iii) group counters in tens, hundreds etc. (iv) rename numbers in expanded form (v) count in order to 1000	1. Sets and Whole Numbers	**Number of a set** 1. Forming subsets of a set 2. Comparing sets. Use phrases: 'more than', 'fewer than' 'as many as'. 3. Comparing nos. Using symbols : >, <, & = symbols : >, <, & = **Numbers and numerals** 1. Separating sets into subsets of ten-members and one hundred-members. Writing numerals 1-100. 2. Place value to thousands 3. Expanded numerals 4. Renaming numerals, e.g. 120 is the same as 100 + 20 5. Counting by 2s, 3s ...

Extract from CRDD (1988, p.34)

will guide effective teaching and learning. The programme is written in columns, headed: objectives, topics and activities/notes as illustrated in Table 2.4. The objectives, in the programmes of study, are statements that describe the specific mathematics pupils are expected to learn under a topic or teaching unit. The activities/notes are brief descriptions of tasks to be carried out in the unit(s).

The topics in both the GMS textbooks and the primary syllabus follow the spiral model of curriculum development which is usually employed in the development of school mathematics curriculum materials. In this model, according to Howson and Wilson (1986), the sequence of topics is almost the same throughout the years with the content increasing in complexity from year to year. The spiral approach is manifested in the arrangement, which I have indicated in Appendix 2.2, which shows topics that are intended to be taught at the various year levels, and also the manner in which both the number and complexity of topics increase gradually from the lower (P1 - P3) to the upper (P4 - P5) primary school years.

As indicated in Chapter 1, a recent study commissioned by the government has revealed that achievement of public primary schools is low in spite of in-service courses organised for teachers to improve the teaching and learning processes in schools, and in spite of the injection of inputs into schools. In response to concerns to raise the quality of work in schools, the government recently commissioned a study to systematically examine teaching and learning in Ghanaian schools for weaknesses in the curriculum, and make recommendations. In the report of this study, Kraft (1994) indicated that teaching in the primary schools focuses on computation skills, learning of formulas, rote practice and teaching as telling. He argued that

> "the current syllabi, textbooks and teachers' handbooks do not meet the highest international standards, nor the current best thinking on sequence, learning and pedagogy and will not prepare Ghanaian students for the needs of the next century" (Kraft 1994, p2).

As a long term solution, he recommended that, "Ghana must prepare a major overhaul of its primary curriculum, including re-writing all its textbbooks, syllabi and teachers' handbooks". Furthermore, in a paper -'*National Programme of Action: Basic Education for All'* - issued recently by the Ministry of Education, the low pupil attainment at the primary level was attributed to the presence of so many subjects and topics in the curriculum that none is adequately treated (GMOE, 1994, p51). The paper also carried the recommendation that "there is a need to revise the English and mathematics syllabi to ensure that basic skills are taught before more advanced skills and knowledge are introduced". However, it is worth noting that no guidelines were suggested for the overhaul or revisions envisaged in both documents.

2.9 Summary

The mathematics schemes currently being used in Ghana - the *Ghana Mathematics Series* (GMS) textbooks and Teacher's Handbooks were products of curriculum projects in Africa which were strongly influenced by the 'new math' movement. The schemes have remained in use in the nation's schools since their introduction in 1975 in spite of concerns raised internationally for countries still using schemes which are products of such projects to adjust their mathematics curricula (Howson and Wilson, 1986 p.14).

If since independence, the nation has not been pursuing educational policies directed at making universal, primary education, and making education relevant not only to the changing needs of a small intellectual elite but the whole society, there would be no question about the appropriateness of the content prescribed in the primary mathematics curriculum. Furthermore, if the schools were filled with learning/teaching resources and teachers have higher teaching qualifications and higher qualifications in mathematics, the curriculum could be said to be adequate for the education system. With Ghana having almost achieved universal education up to the junior secondary level, the fact that schools are staffed with teachers with low teaching qualifications, and schools are far from being considered as educationally well equipped, only a systematic examination of the curriclum and the way it is implemented by teachers can prevent the poor pupil performance being realised in the subject. To do this effectively, there is need to consider the nature of school mathematics curriculum. But before this is considered in Chapter 4, the curriculum changes in school mathematics in the last three decades and the processes involved in the adaptation of the products of these changes, will be discussed in Chapter 3.

PART II

THEORETICAL CONTEXT OF STUDY

CHAPTER 3

CURRICULUM CHANGE AND CURRICULUM ADAPTATION IN SCHOOL MATHEMATICS

3.1 Curriculum Change

Curriculum change in school mathematics can be described as alteration in any of the following: (a) the content of mathematics that is being taught in schools; (b) how the content is being taught; or (c) the rationale and organisational structures of mathematics teaching in schools. In short, curriculum change can be defined as a "concept which applies to any alterations in instruction or in the educationally arranged conditions surrounding it" (Fullan, 1991). Curriculum change is thus a generic concept which embraces a number of related concepts which are often used with no degree of consistency. The related concepts of curriculum change can be grouped into two categories. The first includes concepts pertaining to the nature of change - innovation, reform, and movement. The second includes concepts pertaining to the phases or process of change, which cover the following: development, diffusion, dissemination, planning, adoption, implementation and evaluation.

The term "innovation" is often used to refer to specific curricula changes in a subject which are characterised by well thought out goals. The term "curriculum movement" is used to describe the organised activities of a group of intellectuals with a common ideology and curriculum interest. But the term "reform", is usually used to describe comprehensive changes in the structure and organisation of the educational system as a whole. The nature of curriculum changes occurring in school mathematics in the last three decades may be classified as movements or innovations, but not as reforms. School mathematics has seen major curriculum movements and a number of curriculum innovations in different parts of the world. In the first part of this chapter, the reasons motivating the process or phases of change (including the development, diffusion, and dissemination) of the curriculum movements and innovations will be considered. In the second and third parts, the adaptation of the innovations at the educational system level and classroom level in countries around the world will be discussed.

3.1.1 Reason for changes in School Mathematics

The curricular changes in the last three decades have been motivated in differing degrees by a number of educational and mathematical forces. It is worthwhile then before we attempt to describe the various curricula changes to try to identify the reasons and developments that have stimulated the changes. Since a detailed account of the reasons and developments can be found in a number of sources[1], their discussion here will be rather brief.

[1] See Griffiths and Howson (1974), Sherman (1972), Van der Blij, Hilding and Weinzweig (1981), Howson (1983) and Urevbu (1990).

The century preceding World War II saw the discovery of more mathematics than ever existed in the history of man. Several new results were reached in mathematics and announced. New methods and techniques for solving both old and new problems were developed and new concepts were created. These developments led to a careful formulation of ideas and a greater precision of mathematical language. Sets, and to a lesser extent, functions, emerged as unifying concepts, exemplified in the Bourbaki[2] undertaking (van der Blij, *et al.*, 1981). The development of the ideas of sets and the view that young children could learn much more than educators had previously thought possible advocated by leading psychologists like Jereme Bruner[3] led to the acceptance of Suppes' (1963) premise that "all mathematics can be developed from the concept of set and operation upon set".

The significant role that technology played in the World War II, and the way it was looked up to, in the post-war period and in many newly independent developing countries, as the key to development led to a great emphasis on technology as a force for progress and development. Mathematics, which had played so important a part in these technological achievements, was given special emphasis in the drive for more and better-trained technologists (van der Blij *et al.* op cit.). The impressive socio-economic developments that took place in the post-

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[2] The name adopted by a group of French mathematicians who set out to re-structure mathematics on a set/axiomatic basis. At the school level, the influence of Bourbaki is seen in a rigorous formal treatment of mathematical concepts, with an emphasis on mathematical, especially, algebraic structures. For further information see Howson, Keitel and Kilpatrick (1981).

[3] The dictum of Jerome Bruner that 'any subject can be effectively taught in some intellectually honest form to any child at any stage of development was based on his theory about the sequence of instruction involving the enactive, iconic and symbolic stages' (see Chapter 4 on discovery learning).

war years had led to the provision of more, and expansion of existing, school facilities. This had made it possible for student populations, particularly at the secondary level, to expand massively. The move from an 'elitist' to a 'comprehensive' school system was one reason for the expansion in developed countries. In the developing countries, the implementation of universal primary education policies and improvements in opportunities for secondary and further education had led to the increase in student populations. As a consequence, the proportion of students who remained in school after attaining the minimum 'legal' (or reaching the 'official exit point') for leaving so as to qualify for higher or further education increased.

These developments combined to provide a climate that is conducive to change and motivated the innovators in school mathematics to initiate curriculum development projects in the late 1950s and the 1960s. During this same period in the United States, university mathematicians began voicing their dissatisfaction with the preparation of incoming students. This led to the desire among the mathematicians to improve the content and pedagogy of the school mathematics curriculum. The desire to improve school mathematics to meet developments in education led to the emergence of curriculum development committees or projects and associations[4], and the organisation of several conferences under the auspices of international bodies such as UNESCO, OEEC (and its successor OECD) and ICMI

[4] In England, the Association for the Improvement of Geometrical Teaching(AIGT), which became known as the Mathematical Association, had set a pace for the redesigning of the School mathematics curriculum. Also the Association for Teaching Aids in Mathematics, which later became known as the Association of Teachers of Mathematics, made great contributions to mathematical education. A detailed description of the contributions of the Associations can be found in Howson (1973b).

(the International Commission for Mathematics Instruction). The international conferences attracted all concerned about the need for a broad education in technology to meet the rapid growth of new fields of industry. It had attracted not only mathematicians and researchers but also politicians and administrators from ministries of education and commercial publishers from different parts of the world. However, since the innovations began at the university level, the curricular changes were dominated by mathematicians and reseachers from universities.

Later, the desire to extend the new developments to the greater majority of pupils in secondary education and also to the primary level led to the emergence of several other projects on both sides of the Atlantic. The first major curriculum project was the one initiated by the University of Illinois Committee on School Mathematics (UICSM) which began in 1951 and later over-shadowed by the School Mathematics Study Group - SMSG. (1958). Also among the numerous projects that sprang up in the United States[5] were the Madison Project (1957), New York; University of Maryland Mathematics project (1959); Stanford University Sets and Numbers project (1959); the Greater Cleveland Mathematics Program (1959); and the Minnesota Mathematics and Science Teaching Project (1958). The projects initiated in the United Kingdom included the Mathematics for the Majority project, the Sixth Form Mathematics Project, the School Mathematics Project (SMP), the Nuffield Mathematics Project, the Midlands Mathematical

[5] For information on the evolution and essentials of projects, refer to Sherman (1972). A detailed description of the contributions of these projects can be found in Howson (1973b, 1978).

Experiment, the Council for Educational Technology's Continuing Mathematics Project, and the Scottish Mathematics Group (SMG).

There was also a growing need to 'make comprehensive' the school mathematics curriculum which was originally designed for an intellectual elite. That is, to re-organise the curriculum so as to cater for a broader spectrum of students in secondary schools and to meet the needs particularly of students in the lower half of the ability band. There was also a realisation of the enormous gaps which were opening between what university research workers were examining and what schools taught, and between the demands of computer based technology and the realities of a curriculum designed in the nineteenth century to serve a nation of shopkeepers (Hawes, 1979, p.34). Finally, there was a natural development of an anxiety not to be 'left behind', in what was thought of as a general reform, once the changes had begun in certain 'culturally leading' countries. This development, commonly known as the 'band-wagon syndrome' created a powerful pressure for the diffusion of the curricular innovations in school mathematics in countries around the world.

3.1.2 Strands in the changes in school mathematics

The innovations initiated by the various curriculum committees or projects varied with differences in the ideologies and interests of the members and the nature of support (or funding) obtained. It is useful then before any attempt to discuss the major projects to try to highlight the different ideologies or strands. Howson, Keitel and Kilpatrick (1981) identified five major 'movements' or 'strands', these were: new math movement, behaviourists, structuralists, formative-movement or developmentalists, and integrated-environmentalists. It must be noted that the classifications of the strands Howson, Keitel and Kilpatrick presented were arbitrary and had been selected or classified differently by other educators. Nevertheless, their classifications are the only ones considered here since they were found to be the most adequate for the discussions on the analysis and adaptation of the school mathematics curriculum considered in this study. As the classifications of the varying roles, ideologies or interests of the strands have been made elsewhere (Howson, Keitel and Kilpatrick, 1981) only brief descriptions will be made here.

i) *The 'new math' Movement:*

This was largely a content-oriented movement which showed little interest in pedagogical matters. Often dominated by mathematicians and researchers from universities, the movements major concern was to bring the content of school mathematics more in line with higher (or university) mathematics. The movement spurred the acceptance of what was described as 'new thinking' in mathematics (OECD,1961). The new thinking urged that mathematics should be reorganised so as to emphasise its structure and presented in a uniform language with precision. It regarded traditional school mathematics as lacking in both accuracy and systematic organisation. The new-math movement resulted in changes in the content of school mathematics in the 1960s and 1970s. The quotation below, taken from the description of the new-math approach by

Perreley (1988), illustrates the nature of the changes brought by the new-math innovation into the school mathematics curriculum in the United States:

> "In the elementary schools set theory and the operations on sets were considered before the natural number itself. The mathematical operations were built on corresponding operations between sets. Geometry appeared from the beginning based first on the concept of topological transformation, and later as a projective and metric transformation. The algebraic structures became the framework for both arithmetic and geometry. In the secondary school, the same subjects were developed with greater rigour. In particular, by introducing the vectorial plane, the whole geometric structure was rebuilt, even using algebraic terminology. In a parallel way, there were early introductions to probability and to statistics, subjects completely new to pre-university education, and even to the university curriculum for future teachers of mathematics" (Perreley, opcit, p.872).

In England, Howson *et. al.* (1981) observed that certain traditional secondary school topics like Euclidean geometry and advanced trigonometry, were discarded as having no significant function in the new system and in their place probability, statistics and some computer science were introduced.

ii) *The behaviourists movement:*

The driving ideology or interest of this movement came from educational psychology, that is, outside mathematics. Their concern was re-organisation of the curriculum in a manner that allows knowledge to be broken down into its constituent elements to assist in the creation of step-by-step approach to teaching and to increase efficiency in learning. Their approach was indifferent to content but emphasised particular learning methods, for example, programmed learning, computer-assisted instruction.

iii) *The structuralists:*

The driving ideology of this movement came not only from psychology but also mathematics itself. The major concern of this movement is "the identification of those structures and processes that are specifically mathematical and by means of which professional mathematicians operate" (Howson, 1983). They believe these 'structures of the discipline' exist in a variety of embodiments which children, in learning mathematics, meet over a period of time - on each occasion the structure being employed and acquired in greater depth. This, the structuralists believe, can be achieved through the 'spiral curriculum' and discovery learning. With discovery learning, they are of the view that the exploring student will not only acquire structures, but will behave like mathematicians having full mastery of the structures. The approach to teaching mathematics proposed by the followers of the structuralists is that which requires providing pupils with guided and structured activities. The structured nature of the activities presupposes the activities can lead to the attainment of particular 'objectives', or the outcome of the teaching process will be to some extent certain.

(iv) *The formative or developmentalists:*

The driving force for this movement came from psychology and not mathematics itself. The developmentalist views mathematics as a contributor to more general educational aims which include the development of personality, and of cognitive and affective structures. That is, mathematical structures are viewed not as ends themselves, but as means to attaining more general educational aims. The determinants of content and pedagogy, from the developmentalist's perspective, are therefore the structures of personal development rather than those of mathematics itself. Howson (1983) observed that this movement differs particularly from the last in that "the task of the developer. is not to provide 'embodiments' of mathematical structures, but to find out, and match adequately, the content and methods most likely to develop the pupil's cognitive abilities and affective or motivational attitudes or to enhance their development". Other differences between the approach initiated by this movement and that initiated by the Structuralists, according to Howson (1983) are "the emphasis on reality and the rejection of models, and the way in which curricula units are intended to initiate learning processes rather than to determine them". The emphasis on reality and the rejection of models - 'objectives', 'spiral-curriculum' - reflects a wide gap between the concerns of the developmentalists and that of the behaviourists. The formative oriented approach to teaching mathematics requires not the initiation of guided activities, like that of the structuralist's approach, but rather the promotion of autonomous activities of pupils. Such activities, however, mean the progress of the teaching process and the outcomes of pupils learning will be to some extent uncertain, and for that matter, projects following this approach cannot aim at producing materials in the form of ready-to-use units.

(v) *The integrated-environmentalists:*

The philosophy of the followers of this movement is that the curriculum should provide all forms of learning experiences that will contribute to the personal, social and intellectual development of all students. Areas of learning and experiences in the school curriculum may include experiences which are linguistic, ethical and moral, physical, social and political, scientific, mathematical, and aesthetic and creative. The integrated - environmentalist approach is to ensure students have the opportunity to adequately learn from all these areas by presenting content through a multi-disciplinary context, using the environment as a motivating factor or source of ideas and inspiration. Learning, from the point of view of the integrated-environmentalists, should be centred on "real" problems and it is only by presenting mathematics in multidisciplinary context - theme, topic or project - that learners will encounter such problems.

Changes in school mathematics in Ghana in the last three decades, as will be seen in Section 3.2, were influenced mainly by the new math movement propaganda. Even though the curriculum projects spearheaded by this movement were more concerned with the reorganisation of the content of the school mathematics curriculum, traces of elements of two of the other curriculum strands- the behaviourists and structuralists movements - were incorporated in the development of the materials which were the products of the new math projects. The nature of curricula changes in Africa, and the successes and failures of the projects initiating these changes, are considered in Section 3.2.

3.2 Curriculum projects in school mathematics in Africa: Nature of, successes and failures

The later part of the 1950s and the first few years of the 1960s marked the period that most African countries gained their independence from foreign domination. As indicated in Chapter 2, the search for relevance in education in

Africa during this period led to a number of conferences where African ministers of education advocated for the replacement of the "inherited" colonial system of education and innovations in school curricula. This means by the time that the curricula changes of the 1950s and 1960s reached Africa, the existing political climate was highly conducive to curricula change.

3.2.1 The African Mathematics Programme (AMP)

In response to the demands of the newly independent African states for a curricular reform which would accord with the needs of national growth and development, the African Mathematics Programme (AMP) was inaugurated in Accra in 1961. It was inaugurated under the auspices of the Education Development Centre (EDC)[6] of Newton, Massachusetts - a non-profit American organisation that has been identified with curriculum change in the United States and in South America. The AMP pursued a policy of bringing together Africans, Americans and British educators in English-speaking African countries to influence mathematics education in Africa. To achieve its objectives, it organised writing workshops in Africa which produced the Entebbe Modern Mathematics series

[6] Education Services Incorporated (ESI), which subsequently became Education Development Center (EDC), emerged in the 1950's as an agent for curricular reform in the United States. It owed much to the concern, energy and status of some of the U.S.A.'s leading scientists and mathematicians. The African Education Program (AEP) of ESI was an outcome of an important and influential summer study in African Education, which took place at the Massachusetts Institute of Technology (MIT) in 1961. Of the 52 participants, 14 were Africans and a few British; the majority were American academics. Working parties considered the needs in African education in mathematics, science, language, social studies and teacher training. Three of these led to major international curriculum projects in English-speaking African countries, in mathematics, science and social studies. These projects were handsomely financed by United States Governmental aid funds (AID) and the Ford Foundation, and those in mathematics and science have had enormous influence in African schools, both directly as a result of their own activities in materials development, teacher education and the training of indigenous curriculum workers, and indirectly by demonstrating possibilities and so inspiring other curriculum projects. For further information, see Lockard (1972) and Urevbu (1990).

(Williams, 1971, 1974). The extract below taken from the report on the implementation of the Entebbe Modern Mathematics project in Nigeria, written by Williams (1974), the chairman of the Training College mathematics writing team of the AMP, is a concise description of the Entebbe project.

> Between 1962 and 1969 AMP conducted annual eight-week writing workshops in Entebbe and Mombassa, produced over 80 volumes of textual materials covering primary school, teacher training, secondary and sixth form mathematics. In cooperation with Ministries of Education over 100 inservice courses for teachers, tutors and inspectors were organised. Sample tests and syllabus guidelines were produced for classes and institutions. In the various experimental projects, over a million children were involved in Africa. .....

The AMP schemes were trialled in a small number of experimental schools mainly in the urban areas of the participating African countries. But the full implementation of the Entebbe Modern Mathematics project was delayed for over a decade because it was met with a number of criticisms from the general public. Before considering these criticisms, the successes of the project will be examined.

The mathematics curriculum innovations in Africa led to the reorganization of the topics in the school mathematics curriculum into a sequence, which the designers described as logical, and which can enhance conceptual learning. The innovations also led to the introduction of new mathematical topics into the school mathematics curriculum. For example, sets, logic, programming, different kinds of mapping, transformation geometry, vectorial plane, statistics and probability and a system of new notations, new symbolizations and new terminology. The additional content was intended to increase emphasis on the use of precise language in mathematics, and also on the teaching of mathematical structure rather than on mastery of facts and computational skill which were associated with the traditional methods. The additional topics and the reorganisation of the content of mathematics demanded major changes in the use of traditional methods in teaching the subject. There were emphases on the use of activity and discovery methods which stress understanding and the development of concepts; traditional methods, which were observed to lead to rote memorisation, were played down. The progrmme led to the training of several local personnel to become experts in mathematics education and in the development of, and research in, school mathematics curriculum materials. Finally, it led to the development and publishing of several mathematics schemes (see Lockard, 1968 and 1972) which were used in several parts of the continent.

The first criticism was that the innovators (that is, the early planners and curriculum writers) were largely academics rather than school-teachers, and Americans, few of whom had had extensive personal experience in Africa. In view of this, many mathematical problems included in the Entebbe Mathematics textbooks were meaningless to African pupils (particularly to those from rural environments) as they arose in the context of a society quite different from their own. Secondly, the use of the concept of *set* and the *operations on sets* to develop the entire content of school arithmetic presupposes 'number' should be presented solely as a property of sets. The undue emphasis on sets makes number work, which involves processes other than enumeration (that is, finding the cardinality of sets), to be given little attention. Examples of such number work are those related to measuring or quantifying qualities. In the primary mathematics curriculum those qualities are spatial (that is, length, area, volume, capacity), mass or weight (lightness or heaviness), time (duration) and money (amount). The third criticism concerns the level of, and complexity of, language of the materials developed. The schemes produced included too many new terminologies which incorporated levels and quantities of language often far in excess of the African pupil's capacity to absorb them with understanding. This often reduced most lessons in mathematics in the African classroom to the learning of English words, mainly their pronunciations, instead of their underlying concepts and mathematical significance. That is, symbols and words were mistaken for concepts, means for ends (Howson, 1983). An example of this, in the case of Ghana, is the way in which the operations on sets and the properties have become a subject for study and testing in their own right, and not a means whereby misunderstandings concerning basic arithmetic principles could be diagnosed and remedied.

Another criticism is about the relevance of the contexts in which the mathematics in the books are to be presented. In order to ensure that the materials developed required the use of precise mathematical language, particularly descriptive terminology, the AMP materials, like all other new math materials included mainly classroom and textbook-centred examples at the expense of the mathematical resources of the African environment (Hawes, 1979). The 'new math' was also criticised for the fact that in the majority of countries the movement was directed primarily at students of high ability. Most often therefore, syllabi for the average child were devised simply by omitting all the difficult mathematics.

Adapting 'new math' schemes for the average child in this manner often led to the omission of much of the applications in various topics (Howson, 1983).

Though several other criticisms were made against the project at the different national levels, the final criticism of aspects of the project which have been common to all the participating countries had been the little attempt that was made to relate the work to what was already happening in African schools, which were regarded rather as 'tabulae rasae' (Aldrich, 1969). This lack of relevance is manifested not only in the foreign contexts in which most of the content is presented but also in the pedagogy. The new teaching approaches suggested by the new textbooks played down all forms of traditional teaching approaches which African teachers see as appropriate and can confidently use with learners. In the environment of the African child, however, information is not freely available, and for this reason, good memory plays an indispensable role in the daily life of the child. Wilson (1992, p.129) observed, in this context, that "in a society where memory is highly developed, where much history and tradition is transmitted orally and where sources of reference are not always easily available, rote-learning may well have a more important part to play in a child's schooling". Since such issues were ignored when it came to recommendations on processes of learning that emphasise understanding, the products of the projects, according to Aldrich (1969), were criticised to be stronger on academic elegance than on appropriate pedagogy.

3.2.2 The West African Regional Mathematics Programme (WARMP)

In response to the criticisms of the AMP schemes, two regional programmes, the West/East African Regional Mathematics Programmes (WARMP and EARMP), were established from 1970 onwards to modify the schemes for all institutions in the participating countries. William (1976) observed that

> there was growing demand for the work (in the schemes) to be tailored more specifically to the needs of the countries involved, needs which were not uniform, and which could only be adequately identified by those with extensive experience of African education.

In response to this demand, EDC established from 1970 onwards the two regional programmes -WARMP and EARMP under a much greater African leadership. These programmes led to production of national derivatives of the Entebbe materials in Ghana, Sierra Leone, Liberia, Kenya and Ethiopia. In Tanzania, the Entebbe schemes for primary school level were translated into the national language - Swahili. William (1976 p.199) observed also that by 1980, primary schools in all the participating countries were using textbooks derived from the Entebbe materials by the regional mathematics programmes. The WARMP 'new math' textbook schemes therefore preserved several characteristics of the original Entebbe schemes. The explicit commonalities of content of the Entebbe and the WARMP 'new math' schemes may be stated as:

1. emphasis on the structure of mathematics,
2. emphasis on the ability to abstract and generalize,
3. emphasis on the precise use of mathematical language,

4. emphasis on the mathematical ideas themselves rather than on memorization and drill,
5. de-emphasis on social arithmetic.

As stated earlier (see Section 2.8), the Ghana Mathematics Series textbook scheme, which was introduced into the nation's schools in 1975 was a product of the WARMP. Regional workshops held between 1971 and 1974 at Fourah Bay University in Freetown and the University of Ghana in Accra to develop the textbooks were attended by mathematics teachers from universities, teacher training colleges, and curriculum development departments based in the Ministries of Education of countries that participated in the project - Ghana, Liberia and Sierra Leone (Lockard, 1972). Five Ghanaian officials - one university lecturer, two teacher trainers and two officers from district education offices - participated in the WARMP. The materials from the WARMP were re-edited and adapted for Ghanaian primary schools by a secondary school teacher and a retired teacher training college principal who were both employees of the Curriculum Research and Development Division (CRDD) of the Ghana Education Service. It is important to note that the composition of the group of officials involved in the adaptation of the scheme were mathematics teachers who were working at levels higher than the primary schools. Some never had any primary school teaching experience at all. Like the designers of the original Entebbe materials, the WARMP contributors' relevant and recent primary school teaching experience were not genuinely considered before their appointment even though these are important qualities in tasks that involve decision making on the level and quantity of technical or mathematical language that should be included in pupils' texts.

3.3 Curriculum Adaptation at the national level

Curriculum adaptation involves the modification of a course of study for groups of students different from those for whom the course was originally designed (Blum and Grobman, 1994). The term curriculum adaptation is used both at the classroom level and at the level of an entire educational system. At the latter level, curriculum adaptation is often used to describe the appropriate transfer of curriculum from one society to another. It can also be used to describe the appropriate transfer of curriculum from pupils in an educational system to a new (or reformed) educational system. At the classroom level, however, the term applies to all kinds of curricula changes the teacher decides on, when implementing an official or written curriculum in his or her own classroom. That is, it involves the transformation and modification of curricula by teachers to suit their specific classroom contexts (Smylie, 1994).

Curriculum development from scratch or original curriculum development is an expensive, time-consuming task which demands expertise. The lack of these resources is especially grave in developing countries. These are however countries which feel, more than others, the need to change their national educational programmes. This was particularly true of Africa in the 1960s when many countries had attained political independence. Thus, the adoption and intuitive adaptation of major curriculum developments from abroad was a common feature in many African nations (Urevbu, 1990). This was, in fact a possible shortcut to overcome the constraints, at least particularly, of limited expertise and resources for initiating original curriculum development projects (Blum, 1979). Another reason for adaptation is that a curriculum that is valid for a particular educational system or ability/age group may not be valid if the structure of the system or composition of the group changes. For instance, when a secondary education system becomes comprehensive and competitive selection examinations are abolished, curricula intended for the non-comprehensive (or grammar) school type students needs to be adapted so as to meet also the needs of students in the lower half of the stretched ability band.

Curriculum adaptation at the national or the educational system level may be classified into two categories. One concerns changes that are necessary because of changing ecological situations and the other concerns changes that have to be made because of differences in the needs of the target population. The evidence available indicates that changes made in the adaptation of the major curriculum developments of the United States and Western Europe in the 1960s and 1970s were restricted to changes introduced into the materials because of the changing ecological situation [Williams, 1976; Howson, 1978, 1983; Blum, 1979; Urevbu, 1990]. Not much consideration was given to the socio-cultural background of the recipient nations even though they differed from the donor countries widely in their educational and socio-cultural environments Aldrich, 1969; Wilson, 1992].

The procedures[7] used to select curricula for adaptation have been described by Blum and Grobman (1994) as follows:

(1) Only one choice possible,
(2) First seen, first chosen,
(3) First offer, at recommendation, accepted,
(4) Intuitive choice among some feasible projects,
(5) Intuitive but reasoned choice among feasible projects,
(6) Choice based upon predetermined criteria,
(7) Synthesis of a new curriculum based on others.

The procedures they identified for selection of curriculum for adaptation can be put into two distinct approaches. One entails the selection of a suitable curriculum for adaptation. The other involves analysis of a number of curriculum sources and a systematic synthesis of such sources before the material(s) is adapted. The former is sometimes based on a review of several curricula and may involve any of the first six of the procedures listed above. Under this approach, it is assumed that the adapters have a clear idea about the needs of their target population and have predetermined criteria on which to base the selection. The other approach, which uses mainly the seventh procedure, involves what is described as curriculum analysis. The concept, and process, of curriculum analysis are considered in the next section.

3.3.1 Analysis of curriculum for adaptation

Curriculum analysis is the systematic examination of curricular with respect to a set of concrete concerns (Ariav, 1994). These concerns relate to such features of the curriculum as interrelationships between objectives, and learning activities,

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[7] For details of the nature of procedures, see Blum, A (1979) 'Curriculum Adaptation in Science Education - Why and How? Science Education, pp.693-704.

readability, internal coherence between the rationale and the actual teaching and learning materials, biases and stereotypes, type of evaluation procedures, structure and sequence of instruction, content accuracy and importance, and graphic design. The analysis process is meant to highlight the overt characteristics of a curriculum and disclose its hidden features. It centres on the required or desirable overt features in curricula and examines the extent to which they are absent or present.

Although curriculum analysis can be applied to various conceptions of the term curriculum, it is mostly used in the context of curriculum materials. The purpose of curriculum analysis is to assess how worthwhile a curriculum is regardless of the success of its use in practice. It is not concerned with the observed effects of curriculum materials in use because these outcomes are affected by the whole instructional context and not only by the quality of the instructional materials. Curriculum analysis deals mainly with materials before they are used in the classroom.

An ineffective way of defining curriculum analysis is to contrast it with curriculum evaluation. Ariav (1986) pointed out that "related literature has not made a clear distinction among these two concepts". However evaluation differs from analysis on functional and historical-theoretical grounds. Curriculum analysis had just started to evolve at the time when curriculum evaluation was already a maturing field of disciplined inquiry. The curriculum reform of the 1960s led to a proliferation of textbook schemes and other curriculum materials. This development provoked instances of decision making concerning curriculum selection, adaptation, and implementation among educationists and teachers. The need for practical guidelines and procedures in these decision-making processes provided impetus for the development of schemes for curriculum analysis. Curriculum analysis is usually intended to be performed by trained school personnel or education officers, with relatively limited specialisation in this activity. It is often performed by field-based educators such as principals, librarians, curriculum co-ordinators and developers. Evaluation, on the other hand, is often based in academic institutions and research and development centres. It is conducted by teams of experts and takes a relatively long period of time. Evaluation is supported financially by grants and is performed by state or district administrators, politicians, granting agencies, purchasing personnel, publishers, parents, and community lay people. The literature on curriculum analysis identifies a long and diversified list of roles which seem to be more pragmatic and specific than those of evaluation. These vary from helping teachers to improve instruction, and developing awareness of curricular issues, to identifying trends in curriculum materials. Ariav (1986) contends in this regard, that "curriculum analysis is neither a methodology for evaluation nor an aspect of, or preliminary stage in, evaluation". The two activities can be performed independently of one another, in a sequence where analysis precedes evaluation or vice versa, or in a collaborative mode where the two are interrelated. Unlike evaluation, analysis is rooted in practice rather than in the research tradition. But as a young area of disciplined inquiry, curriculum analysis still lacks a well-established theoretical base.

A scheme (or the set of concerns) for curriculum analysis is a conceptual framework that guides the analysis. A large variety of such schemes has been proposed over the years, but ultimately each particular scheme applied is selected or formed in a way that reflects that user's particular interests and needs. The uniqueness of the analysis process lies with the potential to illuminate the intrinsic educational worth of a curriculum, to reveal its implicit underlying paradigm so as to shed light on its possible strengths and weaknesses. Blum, Kragelund and Pottenger (1981) argued that the two main reasons why more curriculum adaptation teams do not base their work on the analysis of a number of curriculum sources and a systematic synthesis of such sources was the lack of curriculum analysis schemes. In other words, a directory with objectively annotated descriptions of available curricula from which they could choose, or a checklist of decision points which they could consider in the adaptation process were unavailable. In response to this need, particularly during the curriculum reforms of the 1960s and 1970s, several schemes for curriculum analysis were proposed. The need for practical guidelines and procedures in decision-making processes concerning curriculum selection, adaptation and implementation during this period, provided an impetus for the development of over 50 schemes for curriculum analysis (e.g., Eraut, Goad, and Smith 1975, Gow 1977, Gall 1981, Blum, Kragelund and Pottenger 1981).

3.3.2 Schemes for curriculum analysis

Schemes for curriculum analysis are instruments that ensure a systematic analysis process. The variety of existing schemes reflects different interests in this process, ranging from purely theoretical inquiry to the support of praxis-based decision making (Ariav 1994). The underlying assumption behind the development of a scheme is that by providing a conceptual framework the process of judgement would be raised from the mainly intuitive and often indefensible level to a more explicit and conscious level. Even though the evidence available shows that schemes for curriculum analysis are of special importance and are useful in decision making, only a few of them were practically applied and field tested.

Schemes are composed of items which either ask whether a specific element exists in the curriculum, or require that a certain characteristic be fulfilled. The questions or criteria are usually grouped into categories. Items have sometimes an attached measure, for instance, rating scales, tabulations, and checklists. These measures are used to quantify or portray the results of the analysis process. Schemes exist for different subject matters, grade levels and types of materials - printed materials, audio-visual materials and computer software. Schemes exist for different functions, including revealing consistency, biases, underlying values, complexity and thought processes, only to mention a few. Schemes range from a page to a book in length and vary according to the functions and subject matter for which they are intended.

All analysis schemes can facilitate decision making concerning curriculum selection and implementation (or adaptation at classroom level). But only a few are intended, in addition to these, to facilitate decision making concerning adaptation at the national level. That is, decision making that concerns changes that are necessary because of changing ecological situations or changes that have to be made because of differences in the needs of the learners for whom the materials are being adapted. One such scheme is that proposed by Blum, Kragelund and Pottenger (1981) which they named the Curriculum Adaptation Scheme (CAS). Their scheme is made up of a checklist of possible discrepancies between the country of origin of the curriculum and the country for whose system the curriculum is to be adapted. The CAS[8], which is a five page document with ninety-four questions, covers the following five major decision areas of the curriculum:

i) framework, objectives and general approaches,
ii) structure of the curriculum and the organisation of the subject matter,
iii) learners and learning materials,
iv) teacher and teacher materials,
v) administrative questions (Blum, Kragelund and Pottenger, 1981).

An analysis scheme such as the CAS can only be qualitative and not quantitative. The scheme does not propose an "index of adaptability" nor does it lay down rules for accepting or rejecting a curriculum. Essentially, a curriculum analysis scheme cannot be quantitative because different people are likely to give different values to different decision points. In one educational system considerable weight may be given in the process of adapting the curriculum to questions related to subject matter content, while in another system, psychological and socio-cultural issues

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[8] For the detailed description of the CAS, see Blum A.A., Kragelund, Z. and Pottenger III (1981). 'Development and Evaluation of a Curriculum Adaptation Scheme' Science Education, Vol. 65(5), pp.521-536.

may be dominant. The final decision on what to accept and what to reject is based on the considered opinion of people adapting the curriculum.

The CAS checklist scheme was selected for the analysis in this because it is comprehensive and all-embracing. Besides, the scheme includes several questions (or decision points) which address issues regarding the suitability of the curriculum not only to the physical and psychological needs, but also to the changing social and cultural needs, of learners in the adapting educational system.

3.3.3 Using curriculum analysis results for the organisation of the curriculum

When agreement is reached on what to accept and what to reject after the analysis, the task of organising the curriculum follows. Ward (1973) suggested that a cross-cultural adaptation process should involve the following distinct levels of tasks:

Level 1. Translation (language),
Level 2. Adjusting the vocabulary (to make the reading level of the adapted material match the level of the original,
Level 3. Changing illustrations to refer to local experiences,
Level 4. Restructuring the instructional procedures implied and/or specified to accommodate pedagogical expectations of the students,
Level 5. Recasting the content to reflect local world-and-life views,
Level 6. Accommodating the cognitive learning styles of the learners" (Ward, 1973).

With regard to Ward's cross-cultural curriculum adaptation levels, changing illustrations and names in the adaptation to refer to local situations involve low level tasks in the adaptation process. The cross-cultural curriculum adaptation process employed by the WARMP involved largely Ward's three lower levels. These are generally changes necessitated by differences in ecological situations.

The curriculum adaptation process employed in the WARMP textbook schemes was restricted to changes that were necessary because of differences in the ecological situations between the donor and recipient countries.

3.4 Curriculum Adaptation at Classroom Level

In the classroom context, curriculum adaptation refers to the transformation and modification of curriculum by teachers for teaching (Smylie 1994). Research on teaching and implementation of curriculum reveal that teachers adapt the goals, objectives, and formal curricular, to their specific classroom contexts (Fullan and Pomfret, 1977). Clark and Peterson (1986) explained that a curriculum may be adapted during preactive planning for instruction stage or during the instruction process. Decisions that teachers make during preactive planning to transform curricula are based on their considerations of several factors (Clark and Peterson, 1986; Shavelson and Stern, 1981; Smylie, 1994). First, teachers may consider characteristics of the curriculum itself, including its goals and objects, subject-matter content and emphasis. They may examine the recommended tasks and activities and their sequencing as well as instructional materials recommended. They may consider the complexity and difficulty of the content, task and activities, and materials. Then, teachers may compare these various characteristics of the curriculum to their own knowledge and interests including, their knowledge and understanding of the subject matter and their pupils' needs, and their attitude, theories, values and beliefs related to the curriculum and to pedagogy.

Though preactive planning decisions shape the broad outlines of what adaptations are made to the curriculum at the classroom level, such decisions are often altered as a result of developments in the classroom process. Teachers interactive decisions during the classroom process, which comprise interactions between teacher and pupil(s) behaviours, may result in additional transformation of formal curricula (Koehler and Grouws, 1992). While teachers infrequently abandon original plans completely or interrupt the flow of instructional activity to introduce new curricula or instructional routines (Shavelson and Stern, 1981), they continuously make judgements and alter the content and course of lessons according to their assessment of students' responses to instruction, and according to unanticipated classroom events (Green, 1983).

3.4.1 Determing the extent of curriculum adaptation at classroom level

Curriculum adaptation at the classroom level may be evidenced by differences between formal curriculum requirements, in terms of content and pedagogy, and the amount of curriculum actually covered during classroom teaching (Smylie, 1994). This conceptualisation of curriculum adaptation makes a distinction between the formal (or intended) curriculum and the implemented curriculum (see Section 1.2). Not very many studies have used the difference between the two aspects of the curriculum - the intended and implemented - in investigating the extent of curriculum adaptation at the classroom level. Nevertheless, Smylie (*op. cit.*) observed that most of these studies revealed dramatic differences in how much a particular curriculum is taught despite specific mandates about coverage. Clark and

Peterson (1986) found that despite mandates from curriculum departments of State Ministers of Education or District Education Departments, teachers routinely modify curricula by additions, deletions and changes in sequence and emphasis.

The implemented curriculum, which is analogous to the amount of content actually taught and the teaching methods employed, is a function of teachers' decisions related to translating formal curricula into specific instructional tasks and activities. As most studies which have looked at the extent of curriculum adaptation at the classroom level have been concerned mainly with this aspect of the curriculum, the rest of the discussion in this section will be devoted to studies which have looked at teachers' coverage of instructional content.

3.4.2 Studies on teachers' content coverage

Barr (1987) asserts that "although content coverage serves as a major construct in some theoretical formulations, it has received little theoretical treatment in its own right. Further, as used descriptively, it refers to a complex of related conditions". According to Porter *et al.* (1979), 'content coverage', can be distinguished into 'content covered' and 'content emphasised'. The first -content covered - refers to actual counts made of concepts introduced or the range of content (or skills) actually taught (McDonald, 1976). Measures of content emphasised identified in the literature includes such proxies for content coverage as time allocated to content, textbook length or number of pages in textbook devoted to concept or topic (Good et al. 1978; Barr, 1987; Freeman and Porter 1989).

The empirical literature on content coverage can be separated into two main strands. On one investigators are concerned with "the influence of the curriculum on learners' opportunities to learn concepts measured by achievement tests" (Barr, *opcit.*). Most of the studies in content coverage have treated coverage as a condition that acts upon learning autonomously. In these studies, the researchers were concerned with the influence of content coverage (which is analogous to 'opportunity learn') on learners' achievement. Other researchers have considered coverage as a reflection of a complex set of instructional components that jointly affect learning.

Both studies which have explored the influence of content coverage on learners'achievement and studies which have been concerned with content coverage as part of a complex instructional component that influences the whole curriculum, have used similar methods to estimate the extent of coverage. In the first International Association for the Evaluation of Educational Achievement (IEA) study of mathematics achievement (Husen, 1967), teachers from 12 participating nations were asked to judge whether they had promoted the learning of (that is, whether their students had had the opportunity to learn) the content exemplified by each test item. In another study, Chang and Raths (1971) had teachers to evaluate their coverage of content by indicating for test items whether or not they had spent very little to very much time teaching relevant content.

In a recent review of studies on coverage, Barr (1987) pointed out that studies involving teacher estimates of coverage and analyses of curriculum materials suggest a direct relationship between what is covered and what is learned. In the first IEA study, Husen (*opcit*) found a substantial relationship between teacher reported content coverage (or opportunity to learn) and students mathematics achievement. Chang and Raths (1971) also found that differences in achievement between middle- and lower-class schools were associated with the degree of emphasis on content as reported by teachers. International summaries of research on relationship between content coverage and achievement demonstrate that students learn the content of the curriculum they are taught; the more they are taught, the more they learn (Oxenham, 1992). Barr however pointed out that though the relationship between the two had been substantial, it does not necessarily follow that anything that is covered is learned. He contends "content coverage is a condition of learning, one that facilitates learning up to a point but may then depress it if too much is crowded into too short a time". He pointed out however that the true relationship between content coverage and learning is either underestimated or over estimated. It may be underestimated to the extent that direct evidence on learners performance is not presented, and to the extent that tests do not tap content actually covered. On the other hand, the relationship may be overestimated if teacher estimates of coverage reflect both knowledge of and coverage, or if curricular content is not presented during instruction.

Other researchers, by contrast, argue that coverage is a variable that is responsive to and limited by certain conditions. These researchers view content coverage as a reflection of a complex set of instructional components that jointly affect learning. Studies in which coverage has been viewed as an element of instruction have been concerned with the determinants of coverage, and with its effects manifest in learning. Dahlloff (1971) argues that

> "frame conditions - the physical setting, school administration, grouping, class size, structure and objectives of the syllabus, school year, and number of lessons in the year - set temporal and spatial limits on educational processes including content coverage".

Although these conditions and several others may act on the classroom processes either to enhance or limit the amount of coverage, the literature reviewed revealed not very many studies have been concerned with factors that influence coverage as an element of instruction. The few studies identified have examined how the aptitude of learners can influence teachers' coverage (Dohloff, 1971; and Lundgren, 1972), as well as how coverage is influenced by elements of the curriculum (Porter *et al,* 1988; Freeman and Porter, 1989).

Lockheed and Verspoor (1990) reported that most nations have closer to 40 per cent of their teaching time devoted to the national language and 20 per cent to mathematics. With regard to the allocation of time to mathematics teaching, Porter *et al* (1988) found teachers at the same grade level to differ by 9,000 minutes to 6,000 minutes across a full school year. They reported a pronounced lack of balance across concepts, skills, and applications, in teachers' mathematics teaching. They found that, teachers agree in their emphasis on computational skills over concepts and applications, but within that emphasis, percentage of time devoted to computational skills range from a low of 55% to a high of 80%. The remaining time was distributed between teaching for conceptual understanding and applications.

In the Second International Mathematics Study (SIMS), differences were noted between the amount of coverage given topics at both the intended and implemented level in all participating countries. The SIMS preliminary analysis indicated that while applications of all content areas which are topics taught at the primary level are regarded internationally as important, application of topics in natural and whole numbers, decimal fractions, and measurement are regarded as very important (Travers and Westbury, 1989). The study also showed a substantial agreement between all participating systems on the content of arithmetic and measurement included in both their intended and implemented curricula. For arithmetic and measurement, all participating countries indicated that 80 per cent or more of the content presented in the examination were appropriate in their educational systems, this contrasts with the 64 and 69 per cent obtained for geometry and statistics respectively (Travers and Westbury, 1989 p.83). The results of the SIMS show that with regard to the amount of coverage given to topics in different educational systems, arithmetic is the most emphasised in all systems. It also showed that though measurement was covered in educational systems which had a distinctive curricular tradition due in large part to the new-math movement, it was not given as much emphasis as topics in arithmetic.

In another study, Freeman and Porter (1989) found a substantial relationship between emphasis in content presented in textbooks and content actually taught in elementary school mathematics. Mean square contingency coefficients, which measured the extent of relationship between topics emphasised in textbooks and topics emphasised in teachers' actual teaching, were found to range from 0.39 for a teacher who was most dependant on the textbook to 0.23 for another teacher who selected materials from other sources to meet the needs of low achievers in her class. In other words, Freeman and Porter found that emphasis on content in formal curriculum material influenced emphasis on content in teachers' actual teaching. This implies that topics that were mentioned in teaching were also mentioned in textbooks, and also, topics emphasised in the textbook were also most likely to be emphasised in teachers' actual teaching in classrooms and vice versa. Freeman and Porter (*op. cit.*) also reported that content presented in textbooks typically provide little or no guidance for three content decisions that teachers' make during instruction. These include, (a) how much time to devote to mathematics instruction, (b) whether or not to present different content to different groups or individuals, and (c) the strandard of achievement to which children should be held. As a result, they found striking differences in time allocations, group practices in mathematics among teachers using the same textbooks.

3.4.3 Teachers' coverage of teaching methods

Distinguishing between the content (what is taught) and the strategy (how content is taught) of instruction ensures consideration of each (Freeman 1978). Porter *et al* (1988) observed that until recently, most researchers have taken content for granted, focusing their attention on methods instead. Since past research has looked at methods to the exclusion of content, concern has been expressed about the need to direct research to look simultaneously at issues having to do with both content and strategy (Brophy, 1986; Porter *et al,* 1988). Past research on methods had followed an "experimental" format (even though the degree of control is often low) in which two or more methods are compared. Typical comparisons include lecture versus discussion, open versus traditional classrooms, discovery versus expository or prescriptive teaching , phonics versus whole-word methods, and cooperative versus individualistic learning (Bennett *et al,* 1976; Gall and Gall, 1976; Doyle, 1977). Comparisons have also been made in studies on instructional media in which the effects of television, film, video, radio-assisted instruction, programmed instruction and computer-assisted instruction have been compared with each other or with traditional teaching (Doyle, 1987).

Though the content of instruction includes both subject-matter and methods , coverage of the latter is often not considered in studies in content coverage. The main reason for this development, particularly in mathematics, was that most of the studies involving coverage have been concerned with the products (or outcomes) of learning measured by pupils' attainments and not the processes (or how the learning was encounted). Ways in which coverage of methods can be investigated are however different from the ways in which research on teaching methods have been conducted. Unlike the comparative approach followed by most studies in teaching methods, coverage of methods concerns the extent to which a particular teaching method is employed in teachers' classroom practice and not necessarily how effectively the method has improved learners' performance.

It is important to note that none of the studies reviewed had investigated both coverage of content and methods simultaneously. Notwithstanding the absence of studies in the coverage of methods, it will be necessary to treat this aspect of coverage as a separate component. The definition of content coverage stated above (Porter *et al.* 1979) can, in this regard, be used to operationalise coverage of methods. In this study coverage of methods is conceived as related to how often teachers employ teaching skills associated with different teaching styles.

3.4.4 Analysis of classroom discourse

Discourse analysis is concerned with the description and analysis of spoken interaction. One influential approach to the study of classroom discourse was the one developed at the University of Birmingham, where research initially concerned itself with the structure of classroom discourse (Sinclair and Coulthard, 1975). The Birmingham model is certainly not the only valid approach to analysing discourse. Coulthard, Montgomery, and Brazil (1981) have identified other models that researchers have used in analysing classroom discourse. Nevertheless, only the Birmingham approach will be considered not only because "it is a relatively simple and powerful model" (McCarthy, 1991 p12), but also because it was, designed for

> .....classroom situations in which the teacher was at the front of the class 'teaching', and therefore likely to be exerting the maximum amount of control over the structure of the discourse... (Sinclair and Coulthard, 1975).

In this model, a lesson can be described as a series of *exchanges* which in turn are made up of *moves*. A particular exchange consists of a question, an answer and a comment, and so it is a three-part exchange, with each part constituting a move. Below are two examples of exchanges, each with the three moves, taken from McCarthy (1991, p12),

(1) A: What time is it?
B: Six thirty.
A: Thanks.

(2) A: Tim's coming tomorrow.
B: Oh yeah.
A: Yes.

Each of the two exchanges in the example consists of three moves, but it is only in (1) that the first move ('What time is it?') seems to be functioning as a question. The first move in (2) is heard as giving information. The second moves seem to have the function, respectively, of (1) an answer and (2) an acknowledgment. The third move, in each case, is functioning as a feedback on the second move.

In order to capture the similarity of the pattern in each case, (Sinclair and Coulthard, 1975, p26-27) call the first move in each exchange an *opening move*, the second move an *answering move*, and the third, a *follow-up move*. Coulthard, Montgomery, and Brazil (1981, p6) labeled these moves as *initiation*, *response* and *feedback*. It does not particularly matter for the purpose of this study which set of labels are used, but for consistency, the three moves will be referred to as *initiation* (I), *response* (R) and *feedback* (F) in this study.

In the Birmingham approach used in this study, permutations of the three moves *-I, R, and F-* are used to describe different classroom exchange structures or patterns. The patterns are described below and illustrated with examples taken from the researcher's transcription of a tape-recorded lesson (see Box 5.9 in Chapter 5). Where the moves occur in the order I R F, the resulting exchange is described as *'elicit exchange'*. Here, the teacher's initiation is mainly to elicit verbal information regarding the mathematical principle(s) being learned. An example is

Teacher	Hei, Akos, tell us the meaning of this (*i.e. the fraction 3/4 written on board*)?	**(I)**
Pupil 5	Because we have 3, we divide by 4.	**(R)**
Teacher	The explanation is not coming properly. ... Eh..m, Edem, help her..	**(F)**

Where the moves occur in the order I R, but occasionally I R (F), where I has the purpose of directing the pupil(s) to do something, and R being a non-verbal action, the resulting exchange is described as teacher *'direct exchange'*. An example of this exchange is shown below:

Teacher	O.K. someone also should come and write the figure that has been shaded ... (*hands over chalk to a pupil*)	**(I)**
Pupil 5	(*pupil writes* **2/3** *on board*)	**(R)**
Teacher	///////////// (silence)	-

A teacher *inform exchange* often only contains one move, the initiation move (I). It provides mainly information or explanation as in the exchange presented below.

Teacher	So when you have a whole number, a paper like this (raising the sheet in his hands), is what? A whole number. And therefore it can be divided into how many parts?	(I)

In *checking exchange* the moves occur in the same order as in elicit exchange, that, (I R) and occasionally I R (F), but here 'I' has the purpose of checking if pupils have understood a principle being taught or an information presented. An example, is the exchange presented below:

Teacher	Is he right?	**(I)**
Class	Yes	**(R)**
Teacher	Okay, give her a hand	**(F)**

Messenger (1991) observed one weakness in Sinclair and Coulthard's system for analysing discourse, especially when applied to Mathematics lessons. This she explained was that it fails to draw a distinction between pupils' responses which require thought or decisions and those which do not. She identified three types of pupils' responses which she described as *echo*, *routine* and *real*, of which she suggested echo and routine responses do not require thought. Messenger (op cit.) described the three types of responses as

> (i) *Echo* - here the teacher requires the class to echo a word or phrase, or to repeat a response supplied by an individual pupil.
> (ii) *Routine responses* - this includes responses to non-genuine checks of understanding or agreeing with a teacher's statement. ...
> (iii) *Real responses* - requiring thought, understanding, decisions etc. (Messenger, 1991 p. 53).

The two units of analysis considered above– that is, exchange patterns and pupil-responses elicited by teachers' moves– were employed in the analysis of lesson transcripts in this study.

3.5 Summary

There is the tendency for all developments in school mathematics in the 1960s and 1970s to be lumped together under the general heading 'modern mathematics' or 'modern math' depending on which side of the Atlantic the discussion is held (Howson, 1983). But as indicated above, the curricula changes had taken different strands or directions which reflect differences in the aims of their underlying movements. These differences are manifested in the extent of both their emphases on, and the organization of, the two main aspects of the curriculum - content and pedagogy. What was referred to as 'modern mathematics' therefore had two main aspects to its interpretation. Firstly the 'increased' content of the mathematics syllabus and textbooks, and secondly the emphasis on the 'non-traditional' approach to mathematics teaching.

It has been noted that the projects that initated the mathematics curriculum innovations in Africa were concerned with the reorganization of the topics in the school mathematics curriculum into a logical sequence that will enhance conceptual learning as well as the introduction of new mathematical topics into the school mathematics curriculum. The additional content was intended to increase emphasis on the teaching of mathematical structure rather than on mastery of facts and computational skill. The additional topics and the reorganisation of the content of mathematics demanded major changes in the use of traditional methods in teaching the subject. Traditional methods which were observed to lead to rote memorisation were played down and there were emphases on the use of activity or discovery methods which stress understanding and the development of concepts.

The curriculum innovations spearheaded by the AMP and the WARMP (its offspring) have been criticised for a number of reasons. One was, the contributors were dominated by academics who were not involved in school teaching. Another was, the materials were directed primarily at students of high ability and hence the level of, and complexity of, language of the materials developed were too difficult for most students to understand. It was also observed that the materials put a great deal of emphasis on the structures of mathematics and the use of precise mathematical language making it difficult for teachers to include enough learning tasks that would allow students to learn the use, and applications, of the subject.

Bearing in mind that the the 'Ghana Mathematics Series' textbook scheme was a product of the new-math projects which were dominated by experts from certain 'culturally leading' countries, and that its adaptation was made on the basis of 'first offer at recommendation' with no systematic curriculum analysis, it can be argued that there were weaknesses in the process of its adaptation at the national level. To investigate these weaknesses, the researcher selected the CAS checklist scheme (see Section 3.3.2) because it is comprehensive and all-embracing and includes several questions (or decision points) which address issues regarding the suitability of the curriculum. A cursory look, by the researcher, at the curriculum materials (textbooks and teacher's guides) using the CAS checklist scheme raised questions about how adequately decision points related to the relevance, and balance, of the curriculum, were carefully thought about in the adaptation process. *Relevance* means that "the curriculum corresponds to existing needs of pupils and the society" and *balance* means that "the curriculum developers have weighted the importance they have given to each need" (Postlethwaite, 1977, p51). The decision points related to these qualities belong to the three upper levels of Ward's cross-cultural curriculum adaptation tasks which he found to present the most difficulties in the adaptation process, and which were often ignored. Examples of such decisions points identified in the CAS scheme include the following:

Is the content of the curriculum relevant to the aims of the course?

Is the content of the curriculum relevant to the needs of the learners expressed by the overall aims of education?

Does the level of complexity of the content asked for in the curriculum materials, fit the ability of the pupils?

Is the language of the student text (length and complexity of sentence, use of foreign words and mathematical terminology, etc.) suitable for the students?

Is the context, within which concepts and facts are learned, suitable to the students?

Do the examples serve the affective objectives? (e.g. the examples and exercises present situations in which the teacher can induce interest and positive attitudes)

Does the level of competency in intellectual skills (generalisation, decision making, etc.) asked for in the unit, fit that of the students?

Does the teachers' guide contain adequate advice on how to adapt the chapters to different students with varying levels of ability and interest?

Does the teachers' guide contain adequate advice on how to choose among alternative chapters and activities?

Does the teachers' guide contain adequate suggestions for home work? (In terms of quantity and types of activities, e.g. involvement of parents).

Are any forms of social interactions suggested by the unit (e.g. work in heterogeneous or homogeneous groups, competitive work)? If suggested, are they best suited to the students' way of learning?

Do the students' and teachers' roles, as assumed by the unit, fit the teachers' expectations? (e.g. the teacher as authority or as guide, as source or reward or as judge).

The weaknesses in the curriculum adaptation process observed here has definitely resulted in limitations on the suitability of the curriculum materials for both teachers and pupils in schools, and the relevance of the curriculum to the current educational requirements of the nation. There is therefore a need to critically examine the limitations of the curiculum materials. To be able to do this effectively, one will require a good knowledge of the nature of the school mathematics curriculum which comprise the nature of mathematics itself and views about how it is learned and taught. These are examined in details in Chapter 4.

CHAPTER 4

NATURE OF THE SCHOOL MATHEMATICS CURRICULUM

4.1 Introduction

The term *mathematics curriculum* here refers to all instructionally related mathematical experiences of pupils. This, from the point of view of Leithwood (1981), encompasses educational philosophy, philosophy of mathematics, values, objectives, and organisational structures, which indirectly influence what is planned for the individual learners, and materials, teaching strategies, pupils experiences, and assessment, which influence what is actually provided for the learners. In Chapter 1, the three aspects of the curriculum - intended, implemented and attained - were defined. The structure of the intended and implemented curricula comprise three features, namely, (a) learning experiences, (b) teaching methods, and (c) subject matter content. The subject matter content and teaching methods presented in the intended curriculum are what curriculum developers believe are likely to contribute essential and desirable learning experiences in the subject. In order to understand why what is actually taught does not always match what was originally intended, it will be worthwhile to examine the nature of each of these features of the curriculum, with particular reference to school mathematics. The nature of mathematics included in the school mathematics curriculum will be examined first.

This is followed by a look at the different forms of learning experiences that can be encountered in the school mathematics curriculum, and finally, a discussion of the different teaching methods that can be employed to teach the content or provide the learning experiences.

4.2 The nature of school mathematics

Many educationists who have considered the nature of the subject matter of mathematics have distinguished two competing schools of thought with regard to the nature of the subject. In the first, the subject is conceived as static, while in the second, it is seen as dynamic. These two schools of thought were regarded by Griffiths (1978), Lakatos (1978) and Lerman (1983) as "mathematics as a tidy system and mathematics as an untidy activity", "Euclidian and Quasi-empirical", and "Absolutist and Fallibilist" views, respectively. In the words of Lerman (*op cit*), the former concerns the view that "mathematics is based on universal, absolute foundations, and, as such, it is the paradigm of knowledge, certain, absolute, value-free and abstract, with its connections to the real world perhaps of a platonic nature", whilst the latter sees the development of mathematical knowledge as "a process of conjectures, proofs, and refutations, and accepts the uncertainty of mathematical knowledge as inherent in the discipline". In the tidy system, mathematics is said to be viewed from two opposing perspectives: the formalist's or instrumentalist's views and the activist's or Platonist's views (van Dormolen, 1986; Ernest, 1988). Before these views are considered in turn, I shall discuss the elements of knowledge embodied in the subject that are often used when distinguishing between the different views in the Section 4.2.1.

4.2.1 The kernels of mathematics

Views held on the nature of mathematics can be described in terms of the constituents or elements of knowledge embodied in the subject. The constituents of mathematical knowledge or the things that have to be learned to possess mathematical knowledge, are usually expressed by rules, definitions, methods and conventions. While Ernest's (1985) article and several other papers in philosophy of education refer to these constituents as "objects" of mathematics, van Dormolen (1986) in a recent textual analysis of mathematical content termed them as "kernels" of mathematics. He defined kernels as "general expressions that have to be learned as knowledge" and cited some examples, taken from school books, as:

> To convert degrees Fahrenheit into centigrade you can use three computing boxes:
>
> "fahr $\rightarrow \boxed{-32} \rightarrow \boxed{\times 10} \rightarrow \boxed{\div 18} \rightarrow$ cels"
>
> When you must subtract a negative number, you get the same result by adding the opposite number.
>
> The most important methods for proving that two angles are equal are:
>
> (a) with congruent triangles;
> (b) with the theorem: if two triangles have two equal angles, then they have a third angle equal;
> (c) with similarity;
> (d) with arcs (even if there is no circle in the figure, but when this can be imagined).
>
> You are not always allowed to reverse the theorem (van Dormolen, 1986).

The justification provided for designating these elements of knowledge as kernels is that they express sound mathematical experience and contain factual knowledge that constitutes the hard core of mathematics. van Dormolen also referred to problems, exercises, examples and explanations as embodied in situations that serve to make the hard core mathematics understandable, or to consolidate the newly learned hard core, or to show how it can be applied. There is no special criterion to decide whether or not a certain generalised assertion is a kernel. The decision is usually made by the teacher although they are not always free in their decisions. In countries where the syllabus and textbooks are officially prescribed, the kernels are dictated largely by these documents.

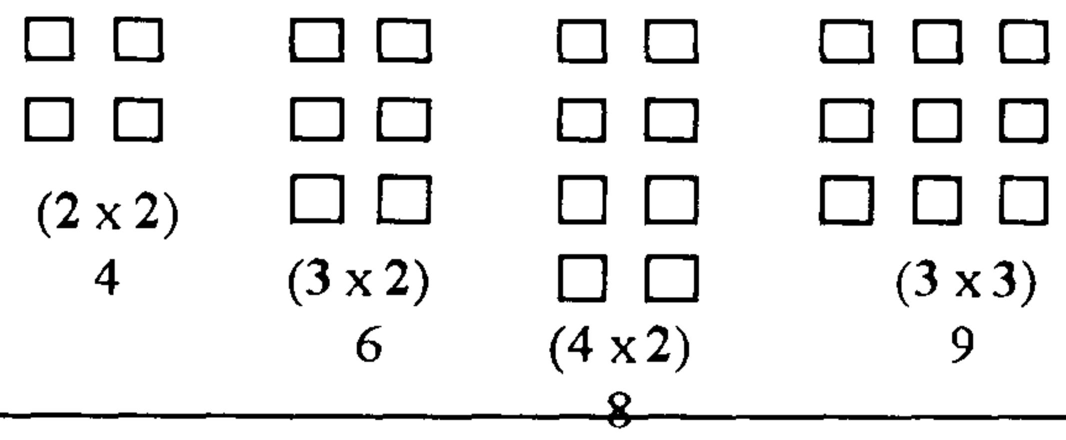
Two significant characteristics of mathematical knowledge that can be used in distinguishing differences in the nature of the subject are its 'aspects' and the 'situations in which its kernels are embodied'. van Dormolen contends these features or characteristics constitute two important dimensions of the subject matter of mathematics. The first, the aspects dimension, which are not necessarily hierarchical, concerns attributes of the content of mathematics that he identified as theoretical, algorithmic, methodological and communicative aspects. To illustrated these aspects, let us consider the kernel - rectangular numbers -, presented in the exercise in Figure 4.1.

Figure 4. 1 An example of a mathematical kernel illustrating the aspects dimension of a kernel.

Rectangular Numbers

Some numbers can be arranged into rectangular patterns.
These are called rectangular numbers

Examples:



Every rectangular number is a product of factors

Which of these numbers are rectangular numbers and why?
3, 7, 10, 12, 15, 16, 18, 21.

Source: CRDD (1986) - Ghana Mathematics Series, Pupils' Book 3, p44.

This kernel has three of the aspects. First, it has a theoretical aspect, because it is a definition which can allow the development of other mathematical theories and as such help us to understand physical and other realities. Secondly, it has a communicative aspect because it gives us the representations of patterns that are rectangular and meanings of words like product and factors. Thirdly, it has a methodological aspect, though this is not explicit, because it tells us how we can verify whether or not a given number is rectangular. The algorithmic aspect concerns 'explicit *how to do* ... rules'. The first example, quoted above on 'changing temperatures from fahrenheit scale to celsius scale', can be considered as algorithmic in nature. This aspect also includes rules such as how to construct certain standard geometrical figures, for example, a perpendicular to a given line.

The second, the kernel context, concerns situations in which the element of knowledge is conceived to exist. Whether, or not, the element of knowledge exists in isolation in textual examples or structured activities, or it is embodied in a problem situation, is referred to as the kernel context. In other words, the kernel context is to do with the contexts in which the kernels are thought to be imbedded. Three categories of contexts can be identified in this dimension. Considering the extent of cognitive activities (like exploring, classifying, constructing, sequencing, hypothesising, checking conjectures, formalising, generalising, abstracting, etc.) involved, the contexts or situations in which the kernels are conceived to be embedded may be listed as: (i) solely in exercises and examples presented by teacher and/or textbooks; (ii) mainly in well-structured and guided activities; and (iii) mainly in exploratory activities and problem situations. van Dormolen contends that kernels clustered in problem situations induce more learning than those presented in isolation in examples to be learned.

Having defined the kernels of mathematics and therefore described its characteristics, I shall now consider the different views held about the nature of school mathematics.

4.2.2 Instrumentalist view about the nature of school mathematics

In the instrumentalist view, mathematics is a set of concepts, rules, theorems and structures, which according to Ernest constitute "a bag of tools". In his description of the instrumentalist conception of the nature of mathematics, Ernest (1988) said it is

> " the view that mathematics, like a bag of tools, is made up of an accumulation of facts, rules and skills to be used by the trained artisan skilfully in the pursuance of some external end. Thus mathematics is a set of unrelated but utilitarian rules and facts".

These tools are seen as a cultural heritage that must be passed on, partly at school. To acquire these tools one needs certain skills, such as algorithmic skills and deductive reasoning ability. The latter is considered to be the only proper way of reasoning in mathematics. Intuitive and plausible reasoning are not considered as genuine mathematical activities.

From the point of view of the instrumentalist, school mathematics consists of kernels which, though logical in nature, are largely theoretical and algorithmic and mainly include facts, formulas and procedures existing in texts to be learned for some future use. It involves activities that call for mechanical use of rules and procedures without requiring much thought - especially computation and drill activities. The instrumentalists' view about the nature of school mathematics may be summarised as follows:

- mathematics is logical, its study trains the mind to work logically; mathematical activity is like a 'mental calisthenics'.
- mathematics is predictable, absolute, and fixed; its content offers little opportunity for creative work;
- mathematics came about as a result of basic needs that arise in everyday life;
- mathematics is a tidy activity, its content is cut and dried; procedures and methods used in mathematics guarantee right answers
- mathematics is an exact discipline - free of ambiguity and conflicting interpretations.

4.2.3 The Platonist view about the nature of school mathematics

The Platonist view maintains that the objects of mathematics (or 'pieces of knowledge that constitute mathematics') have independent existence. This means, the objects of mathematics belong to an "independent, pre-existing world outside the mind of the knower" (Kilpatrick, 1987, p.3). Platonism presents mathematics as a subject that consists of descriptions of the relationships and truths connecting mathematical objects into a body of knowledge. Since they locate the source of the objects of mathematics in a pre-existing static structure, platonists see mathematics as an inert body of knowledge which teaching transmits to the pupil. According to Ernest (opcit), it is the view that mathematics is

> ...a static but unified body of knowledge, a crystalline realm of interconnecting structures and truths, bound together by filaments of logic and meaning. Thus mathematics is a monolith, a static immutable product. Mathematics is discovered, not created (Ernest, 1988).

In this static view of mathematics, the subject is considered as a body of knowledge which is acquired mainly through discovery. The process of acquiring knowledge of kernels, in this view, involves being engaged in activities like classifying, ordering, quantifying, exploring patterns, generalising, abstracting etc., etc. Though intuitive reasoning is considered as useful mathematical activity, the emphasis here is on *what* the pupils discover, like patterns, relationships, concepts and structures (that is, the products of the activity) and not *how* (the process leading to the discovery). The theoretical and the algorithmic aspects of mathematics, which are emphasised by kernels of the instrumentalist view, are stressed too in this view, but more emphasis is placed here on the communicative aspect. The communicative aspects is emphasised here because it is this aspect which allows the learner to demonstrate whether or not he or she has discovered what is expected to be learned. Thus, for a pupil to be said to have discovered a principle or concept, he or she should be able to express (that is, communicate) this, either verbally or in written form (or both), logically using the appropriate conventions.

School mathematics, in this view, comprises topics in which the kernels of mathematics are presented in an interrelated (or integrated) and logically connected whole and not in isolation. For instance, the concept of number and the four arithmetic operations (addition, subtraction, multiplication and division) are thought to be embodied in the structure of sets, and as such, the teaching of sets should be considered before the natural numbers. The platonists conception of mathematics may be summarised as:

- mathematics is a static but unified body of knowledge; its content is fixed and predetermined, as it is dictated by ideas present in the physical world;
- mathematics is an organised and logical system of symbols and procedures that explain ideals in the physical world;
- mathematics is accurate, precise, consistent, free from ambiguities and largely abstract;
- mathematical content is coherent; mathematical topics are interrelated and logically connected.

4.2.4 The Fallibilist view about the nature of school mathematics

In the untidy system, mathematics is viewed as a dynamic subject which belongs to a continually expanding field of human creation and invention. Doing mathematics, in this system, involves doing what mathematicians do and not the mere acquisition of technical skills or standard techniques for solving problems which have been formulated and previously answered by others (Griffiths, 1978). Ernest (1988) described this perspective as the "problem solving view" because the kernels of mathematics, in this view, are believed not to be independent of the context in which they are practised but embedded mainly in problem situations. What the pupils discover is not the ultimate goal of mathematical activity, but so long as the activities they engage in are mathematical, it is regarded as genuine mathematics. Thus not only the results of the mathematical working process in the form of formulas and theorems (thus, knowing mathematics) and the applicability of these results (thus, doing mathematics) are seen as important but also the working process itself. In other words mathematics is also an activity. This activity involves a process of enquiry occurring in problem situations from which new knowledge arises.

The problem solving view parallels the educational view that the process of doing mathematics lies at its heart (Cockcroft, 1982). The problem solving view about the nature of mathematics has also been referred to as the "fallibilist view" because mathematicians are not infallible and, as such, "their products, including proof, can never be considered final or perfect but may require renegotiations as standards of rigour change" (Ernest, 1986). From a fallibilist perspective, according to Lerman (1990), mathematics develops through conjectures, proofs, and refutations, and uncertainty is accepted as inherent in the discipline. The problem solving view of the nature of mathematics may be summarised as follows:

- mathematics serves as a tool for the sciences and basic needs that arise in everyday life;
- mathematics originated from the practical needs of everyday life, the sciences and mathematics itself;
- mathematics is a challenging, rigorous and abstract discipline;
- the study of mathematics provides opportunity for a wide spectrum of high-level mental activity and sharpens one's ability to reason logically and rigorously;
- mathematics is not a finished product; it is an untidy activity and leads to results that are open to revision.

4.3 The nature of school learning

To understand why teachers use different teaching methods, one will require a broad view of the major categories of school learning. The perspectives provided in this section, mainly psychological in nature, are to facilitate such a knowledge.

4.3.1 Reception and Discovery learning

Psychologists contend that new knowledge and skills may be acquired through two different processes of learning. These processes, according to

Ausubel (1961) are reception learning and discovery learning. In reception learning, the entire content of what is to be learned is presented to the learner in the final form. The learning process does not involve any independent discovery on the part of the learner. The learner is required only to internalise or incorporate the material that is presented into what is already known so that it is available or reproducible at some future date. In reception learning, Ausubel and his associates believe the learning experiences presented by the teacher are to enable pupils to assimilate new learning materials (or see the interconnections between the new concepts) and what already exists in their minds. To achieve assimilation is to experience what Ausubel (1963) and other theorists term as "meaningful learning".

In discovery learning, the content that is to be learned is not given but it must be discovered by the learner before its meaning is fully incorporated into what the learner already knows or into his/her cognitive structure. The understanding or appreciation of the truth of a mathematical principle comes mainly as a result of the pupil's own effort and not only by the teacher's explanations. Discovery learning does not mean discovering something first, that is, in an absolute sense, but in a relative one, as if one were the first to do it. The child is said to have learned by discovery if the solution of a problem or the demonstration of the truth of a mathematical proposition has not been notified to him or her by anybody. Learning through discovery involves a sequence of strategies which include

(i) exposing the elements of the concept(s) in a form and order that will enable the learners to form hypotheses;

(ii) asking questions or providing more evidence that will confirm (or not) the various hypotheses that they appear to be acting on; and

(iii) stating (or sometimes the teacher pointing out) the relationship which is the desired formula or principle expected to be inferred from steps (i) and (ii).

Bruner *et al.* (1966) contends that to promote discovery learning, the domain of knowledge or the principle being learned, should be represented to learners in a sequence in three different ways: (a) enactively, that is, by a set of actions which present concrete experiences; (b) iconically, that is, by images or graphics; and (c) symbolically, that is, by verbal symbols or by logical propositions. He asserts that the normal sequence of instruction for most learners is from enactive through iconic to symbolic representations, however some learners can skip the first or second representations, if they have the appropriate background of experience. In the formation of a concept or in the learning of an item of knowledge, similar stages or phases of instruction which together constitute a cycle have been found by researchers in mathematics education. Similar sequences or stages, reproduced below, were obseved by Dienes (1960) and Polya (1963).

Dienes	**Polya**
The preliminary or play stage corresponds to rather undirected, seemingly purposeless activity usually described as play. In order to make play possible, freedom to experiment is necessary.	A first, exploratory phase which is close to action and perception and moves on an intuitive, heuristic level.
The second stage is more directed and purposeful. At this stage a certain degree of structured activity is desirable.	A second, formalising phase ascends to a more conceptual level, introducing terminology, definitions and proofs.
The next stage really has two aspects: one is having a look at what has been done and seeing how it is really put together (logical analysis); the other is making use of what we have done (practice). In either case this stage completes the cycle, the concept is now safely anchored with the rest of experience and can be used as a new toy with which to play new games (Dienes, 1960, p 39)	The phase of assimilation comes last: there should be an attempt to perceive the 'inner grounds' of things; the material learnt should be mentally digested, absorbed into the system of knowledge, into the whole mental outlook of the learner. This phase paves the way to applications on one hand, to higher generalisations on the other (Polya, 1963, p 605).

These stages imply that discovery learning is largely activity oriented for both the teacher and the learner. The teacher sets up the activity and continues to play a role, as the learners work through the activities, acting in accordance with the responses and progress of the learners in order to lead them to discover the required concept(s). The importance this process of learning attaches to activity and the involvement of the child in his or her own learning gives it a number of advantages which explicates why instructional experts like Bruner *et al* (1966) and Biggs (1969) advocate that it should constitute a greater part of the child learning experiences in the primary years. Conner (1990) contends the distinct advantages of this process, as suggested by Bruner *et al* (1966), are:

(i) It will increase intellectual potency.
(ii) There will be a move from extrinsic to intrinsic rewards.
(iii) The child discovers how to discover.

(iv) There will be an improvement in memory.

These are, however, not without disadvantages and researchers favouring the process, according to Riesedel and Burns (1973, p1163), have identified these as:

a) requires a vastly increased expenditure of time;
b) causes frustration when children fail to discover;
c) without adequate consolidation it is likely to be a vain pursuit because it is incomplete and may lead to frustrating perplexities as the learners are unaware of restrictions that logic imposes on possibility and reality;
d) is not equally appropriate for all children, thus the teacher may underestimate the cost in loss of communication for the pupils who do not discover.

4.3.2 Meaningfulness of School Learning

Besides being acquired through discovery or reception learning, another important characteristic of the process whereby new knowledge and skills are acquired in the school context is its meaningfulness. This concerns whether or not the new knowledge is interconnected with what is already known. Ausubel *et al* (1978) observed that many tend to confuse reception learning with rote learning and are of the view that materials represented verbally are necessarily rote in nature, and also that "reception learning is invariably rote while discovery learning is inherently and necessarily meaningful" (pp.342). Commenting on this confusion earlier, on why the two elements of the dimension should not be contrasted, Ausubel and Robinson (1969, p45) stated that

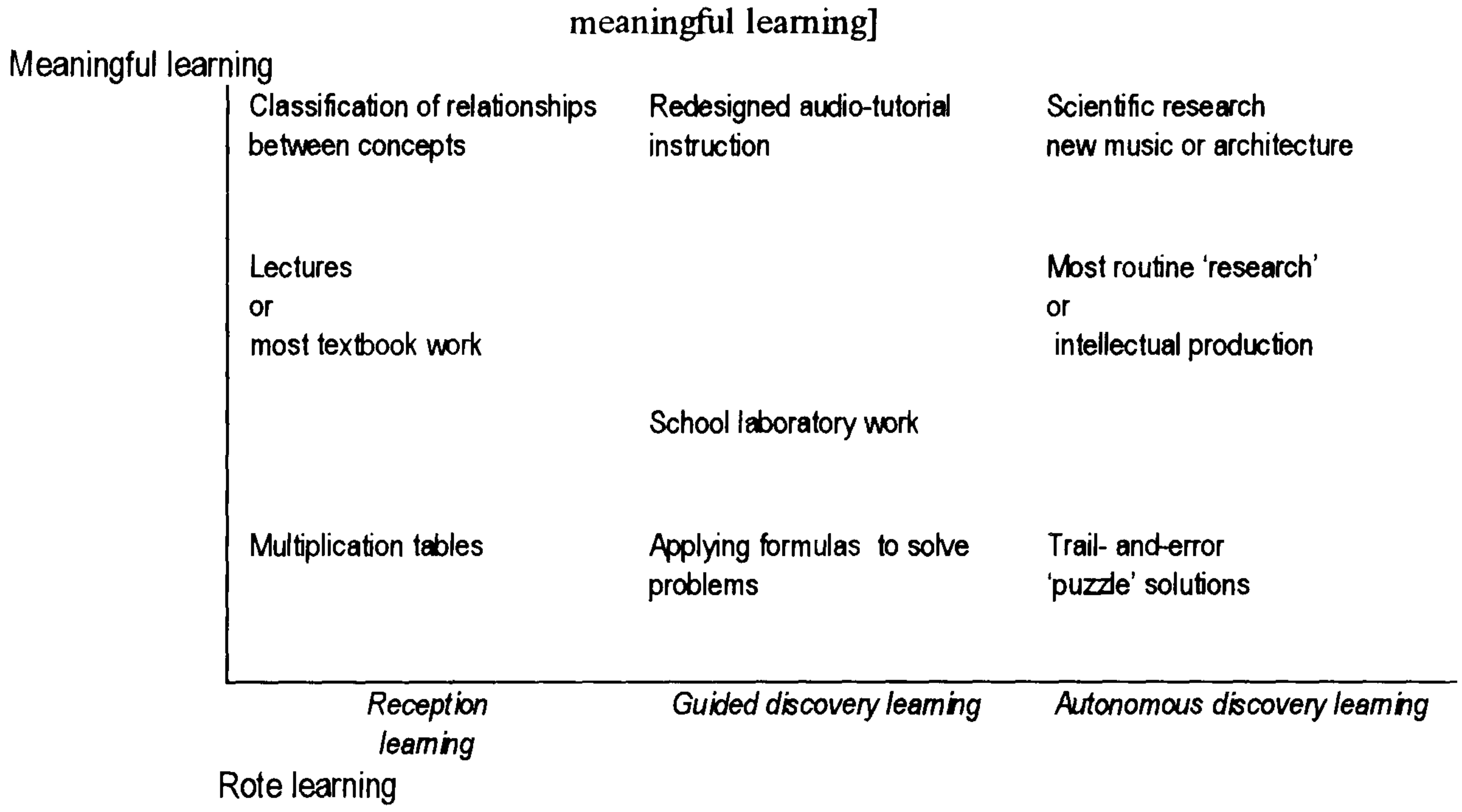
> ...learning tasks can be found which exemplify all combinations of the meaningful/rote dimension and the reception/discovery dimension. The independent nature of the two dimensions in question must be stressed because of the tendency to confuse them, and to assume that all reception learning must be rote in nature, and, conversely, that all discovery learning must be meaningful.

They explained that regardless of the process by which the learning is acquired (that is, be it reception learning or discovery learning), the learning which results can either be rote or meaningful depending on the conditions under which the learning is encountered.

Based on these views, Ausubel and his associates suggested a framework (reproduced in Figure 4.2) which they used to illustrate the view that each distinction *(rote* versus *meaningful*, and *reception* versus *discovery*, learning) constitutes an entirely independent dimension of learning. They referred to these as "the two fundamental dimensions of school learning".

Figure 4. 2 *Reception/discovery versus rote/meaningful dimensions of school learning*

[Reception learning and discovery learning are on a separate continuum from rote learning and meaningful learning]



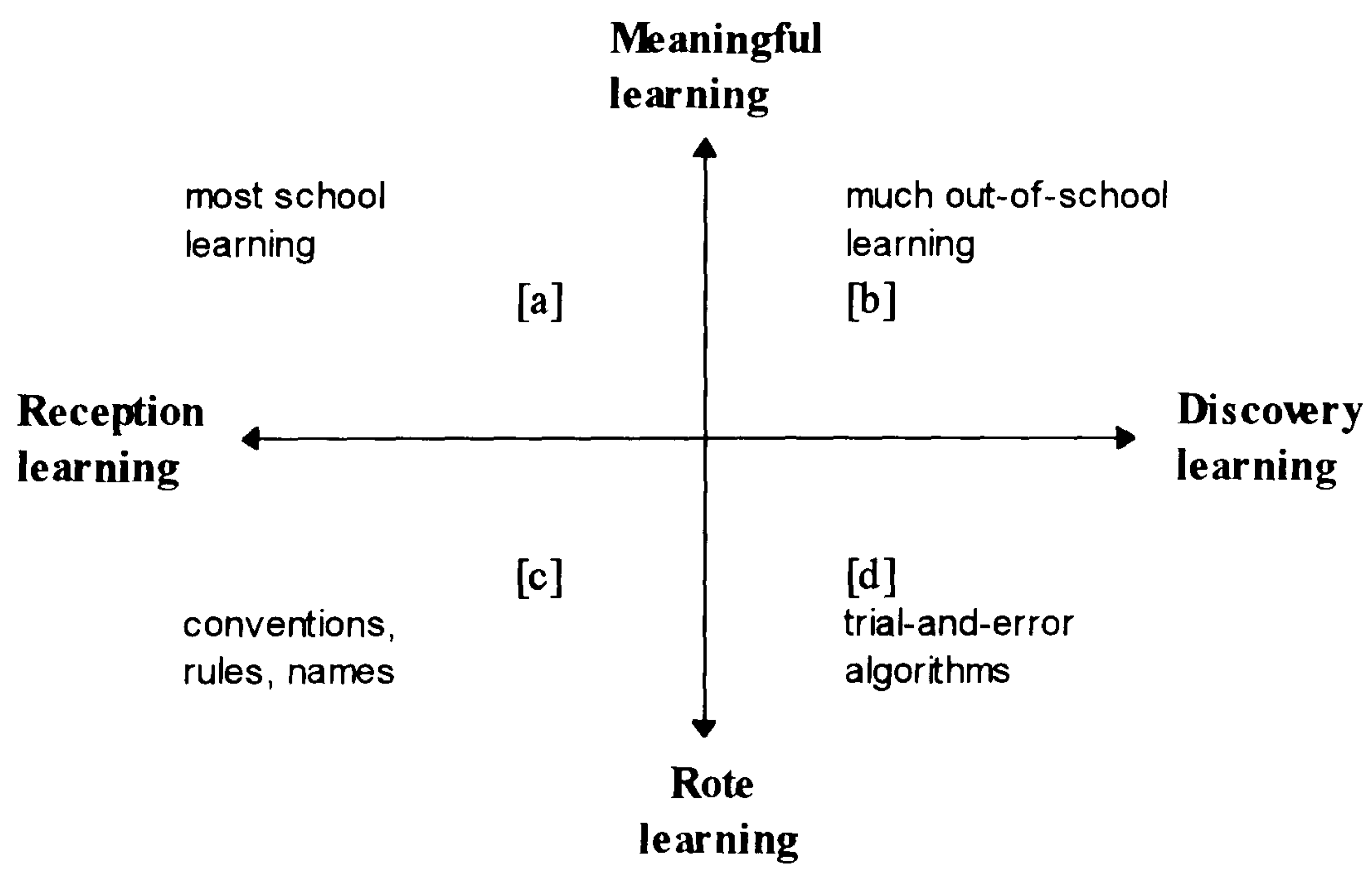
Ausubel *et. al.* explained that in rote learning, the new principle that is to be learned is acquired in an isolated way without links and connections with what is already known. Since there is lack of relationship between the newly acquired element of knowledge to the already developed structure of knowledge, Perelley (1988) argues that "the only practical way of retaining it in the memory is that of mechanical and stereotyped repetition". However, in meaningful learning, the new principle to be learned is encountered in a manner which makes it possible for the learner to connect it with other concepts and skills already acquired. Commenting on the meaningfulness of school learning, McClelland (1983) argued that

> no learning is ever entirely rote nor entirely meaningful, but pure rote learning would form no link with anything already known, would not help further learning and would necessarily be learnt 'by heart'. Learning is meaningful according to how well it fits into the network of what is already known, extends it, and improves the ability to learn still more.

and gave the following three conditions as necessary for meaningful learning:

1. What is to be learned must make sense, or be consistent with experience. This is logical meaningfulness. (The material does not have to be true).
2. The learner must have enough relevant knowledge for the material to be within grasp.
3. The learner must intend, or be disposed, to learn, meaningfully, that is, fit the new material into what is already known rather than to memorise it word-for-word.

McClelland and Perelley described the different forms of learning encountered by pupils in learning mathematics, with reference to the dimensions identified by Ausubel, using the framework illustrated in Figure 4.3.



SOURCE: Perelley, (1988).

Figure 4. 3 *The two fundamental dimensions of school learning*

The framework distinguishes the two aspects of school learning– the degree of meaningfulness, and the way in which the content to be learned is to be encounted. They pointed out that the nature of learning experiences provided in actual classroom practice in the teaching of school mathematics can be placed in quadrant [c] of Figure 4.3. They explained that these experiences are mainly learning that involve mechanical repetition of what has been explained by the teacher or contained in a textbook. They also argued that most of the learning that occurs in schools is organised below the horizontal dimension, that is, in quadrants [c] and [d] but with more emphasis on the former which ignores the importance of activity and the involvement of the child in his/her own learning. Many educationists are of the view that school learning should instead be organised above the horizontal dimension but there is no consensus on the quadrant in which this is to be organised. Ausubel and McClelland argue meaningful reception or quadrant [a] is best since learning experiences that can bring about meaningful discovery are mainly out-of-school learning. Agreeing, but not completely, with this argument, Perelley contends good learning could be obtained between quadrant [a] and [b], and not wholly in quadrant [a].

4.3.3 Meaningful reception learning

The strategies that can be employed to induce meaningful reception learning in pupils include a model for organising learning materials for effective learning which instructional experts have described as the "advance organiser model"

(Ausubel, 1963; Joyce & Weil, 1986). The model is so called because the first of its three phases emphasises the presentation of or experience with the 'organiser' which includes data from which the new concept(s) or the essential attributes to be learnt could be identified.

Figure 4. 4 *Advance Organiser model*

PHASE ONE: PRESENTATION OF DATA AND IDENTIFICATION OF CONCEPT	*PHASE TWO:* TESTING ATTAINMENT OF THE CONCEPT
Teacher presents labelled examples. Students compare attributes in positive and negative examples. Students generate and test hypotheses. Students state a definition according to the essential attributes	Students identify additional unlabeled examples as yes or no. Teacher confirms hypotheses, names concept, and restates definitions according to essential attributes. Students generate examples.
PHASE THREE: ANALYSIS OF THINKING STRATEGIES	
Students describe thoughts. Students discuss role of hypotheses and attributes. Students discuss type and number of hypotheses.	

Source: Joyce & Weil 1986: p.34.

The three phases of the Advance Organiser model have been reproduced Figure 4.4. To illustrate this model, let us consider the teaching scenario (Scenario 1), presented below, to see the nature of learning experiences involved.

Teaching Scenario 2: Mrs Addo

> Mrs Addo is a Class 6 teacher at Peki Avetile Primary school in the Volta Region of Ghana. She begins the teaching of perimeter by revising the concept of polygons using cut-out shapes - circles, triangles, squares, rectangles, hexagons and octagons. She shows the class the shapes and asks them to describe their properties - number of sides and square corners or right angles. She draws two rectangles on the chalkboard and writes down the formula for perimeter, "$p = 2(l+w)$. With questioning, she is able to get pupils to identify the length (l) and the width (w) and substitute these into the formula to calculate the perimeter. She works one or two examples and asks for some volunteers to try some more on the chalkboard. She writes five similar exercises from the mathematics textbook on the board and asks the pupils to copy it in their notebooks and do as homework. The next day she gives out the rectangular cut-out

shapes to pupils after checking and discussing the homework. She asks the pupils to measure their perimeter by winding strings around the shapes and measuring these, and also measure their lengths and widths using a ruler. Mrs Addo writes the results on the chalkboard in a chart as shown below:

SHAPE LABEL	Measured PERIMETER(P)	Measured LENGTH (*l*)	Measured WIDTH (*w*)	Calculated PERIMETER(*p*)
A	28 cm	8 cm	6 cm	28 cm
B	17 cm	5 cm	3½cm	17 cm
C	25 cm	8½cm	4cm	25 cm

She asks pupils to compare the perimeters "*p*" and "P", and explain why "*p*" is "2 times (l+w)". As class exercises, she gives pupils a table, similar to the one above, with a missing item in each row for pupils to complete. On the third day she gives word problems and more difficult exercises on the topic. The entire unit on perimeters takes about 4 class periods.

As shown in Figure 4.4, the first phase, in addition to clarifying aims and prompting awareness of relevant previous experiences, includes the presentation of the organiser. In the teaching scenario presented above, the organiser consists of the concept of perimeter which is distance round a plane figure, and the rule for perimeter of a rectangle which is $p = 2(l+w)$. With the help of the cut-out shapes Mrs Addo and the pupils explored the organiser and the learning tasks at the first phase. By the help of the shapes pupils were made to encounter many similar situations in which the new principle, perimeter, is embedded. The chart the teacher led the class to build on the chalkboard provided opportunities for pupils to spot and compare the common patterns between the sides of the shapes on the one hand, and their perimeters on the other. These opportunities did not make the pupils to see just the rule(s) but also their attributes which enabled them to determine whether or not the rule(s) can be applied when the conditions are varied in similar situations.

4.3.4 Learning through construction

Learning through construction expresses the view that knowledge is constructed by the individual, and that, knowledge is neither passively received from the environment nor acquired by discovering an independent pre-existing world outside the mind of the knower (Kilpatrick, 1987; von Glasersfeld, 1988). In this view, "knowledge schemas (structures)", according to Skemp (1989), have to be constructed by every individual learner in his own mind. No one can do it directly for them. Knowledge schemas are constructed from personal experiences and from social interaction. What is learned from new experiences and interactions depends on the learner's existing knowledge schemas as it is these which determine what is perceived as relevant and therefore observed.

Construction of knowledge, according to Jaworski (1992), involves a constant process of meaning making and common knowledge is a negotiated synthesis of one's intentions, interpretations, self-monitoring, elaborations and representational constructions. Perelley (1988) asserts that this "constructivist" view emphasises three interrelated elements of mathematics learning:

> First, mathematics learning is a process of knowledge construction. .... Second, people use available knowledge to construct new knowledge. .... Third, learning is highly tuned to the situation in which it takes place (Perelley, 1988, p 875).

The first suggests that effective, learning depends on the intentions, interpretations, self-monitoring, elaborations and representational constructions of the individual learner. The second suggests what is learned depends on elaboration and extension of prior knowledge. In this regard, Skemp (1989) contends that good teaching can greatly help. The more abstract and hierarchical the knowledge schemas which are to be built are, the more this help is needed. The last of the elements, suggests that knowledge is retained in a meaningful and stable way if it is embedded in some internal and/or external organisation. In other words, skills and knowledge are not independent of the context in which they are used and practised.

Though several similarities and differences can be identified between the constructivist theory and the arguments for discovery learning (see Orton, (1994, p42), these will not be considered here. This is because though the theory of constructivism has a long history, its impact on the school mathematics curriculum has been recent. This implies that the theory did not influence *per se*, the curriculum developments of the last three decades. Bearing in mind that the discussion in this chapter is to facilitate the analysis of curriculum materials developed during this period, a detailed consideration of the constructivist view will, in this regard, not be very relevant. However, to be able to advise on the adaptation of curriculum materials developed in one social context for another, one must be aware of how cultural differences, which influence learners' expectations in school learning, around the world can limit the use of constructivism in many countries. Constructivism calls for teaching methods which appear to diminish the direct teaching role and authority of the teacher. In other words, constructivism calls for teachers to move away from traditional teaching methods. One of the problems of introducing teaching methods that favour constructivism, according to Orton, is

> .....we all, to a greater or lesser extent, live within a cultural milieu which has traditionally encouraged the view that the teacher is the authority and the ultimate source of knowledge

> and wisdom, at least within school. .... For some countries .... children are expected to respect and listen to their elders without question, they expect to be told what to do and to be instructed in the ways of the social group, they do not expect to be placed in the position of having to be creative, and they do not easily accommodate to a role in which they may debate with and even question the view of the teacher (Orton, 1994, p 55).

In countries in which the learners' expectations in school learning match those described by Orton, it must be noted that introducing methods that encourage children to develop their own understanding and construct their own knowledge, may take time to develop.

4.4 Teaching in the school context

To understand the nature of similarities and differences that exist between methods of teaching and learning presented by the intended and implemented curriculum of a given educational system will require a good knowledge of teaching in the school context. The object of this section is therefore to provide a broad background to such knowledge which will enhance discussions about classroom practices and recommended practices in teaching primary mathematics. This will begin with an examination of the definition of teaching and a framework for analysing teaching.

4.4.1 Perspectives on the definition of teaching

In many African languages particularly those spoken in Ghana, the word used to express the act of teaching is what will be translated in English as "showing". "*Fia*", "*kyere*" and "*tso*", which are all terms for the act "teach" in three different

Ghanaian languages, Ewe, Akan and Ga respectively,[1] are all used in the same sense as the word "teach" is used in the English language. "*Nufiala*", the word for "teacher" in the Ewe language, can be translated literally into English to mean "a person who *shows* things". The word "teaching", in all Ghanaian languages, has a recent history. It entered the vocabulary of these languages in the last half of the eighteenth century when the first early schools were opened in the country by Christian Missionaries from Europe (McWilliam, 1959). Since the teaching offered in the early missionary schools beside biblical instruction included only reading and writing and occasionally arithmetic the teacher was seen as one who showed others 'things' and how to do "things". 'Things', in this sense, refer to signs or symbols that can be read or used in communicating effectively. Teaching is therefore conceived in these languages as showing through symbols. Considering teaching from the point of view of showing someone something is not peculiar to only African languages. Tracing the etymology of the word in English, Smith (1987) explained that it was derived from an old English term whose root can be traced to a word meaning "show". He stated that:

> It comes from the Old English *taecan* that is in turn derived from the Old Teutonic *taikjan*, the root of which is *taik,* meaning to show, and is traceable to Sanskrit dic through pre-Teutonic *deik*. The term "teach" is also related to "token" - a sign or symbol. "Token" comes from the Old Teutonic word *taiknom*, a cognitive with *taikjan*, Old English *taecan*, meaning to teach. So "token" and "teach" are historically related (Smith, 1987 p 11).

Smith's account demonstrates that the word had been used, at one time in English history, in the same sense as it is used in many African languages today. That is, to

[1] The most common languages spoken by more than 70% of the population of Ghana. For further information of languages spoken in Ghana, see (Adjabeng, 1980)

teach means to show someone something through signs or symbols and to use signs or symbols to communicate thus, to evoke responses about events, persons, observations, findings and so forth. In both the African and English derivations discussed here, the word "teach" is associated with the medium in which the task of teaching is carried out. To teach is seen as to do something to someone; tell a person something, show a person how to do something, and to give a person a lesson on a topic. This is the sense in which the word is used in everyday language. This, in fact, is the sense in which the word has attained the conventional definition usually expressed as "teaching is imparting knowledge or skill" (Onion *et al.*, 1933, p 2139).

Various procedures are employed in imparting knowledge and skills. Instruction, demonstration, dialogue and practical involvement are examples of such procedures. To see teaching as merely imparting knowledge and skills is to probably say the act is committed largely to the first two procedures, that is, instruction and demonstration which ascribe a dominating role to the teacher. Today the expanding knowledge in psychology about how children learn has not only made this traditional and dogmatic view of teaching, particularly in the early years of formal education, less acceptable; but has also generated different perspectives about what should be an appropriate definition of the term. In this study however, only the perspectives on the definition of teaching which are philosophical will be discussed.

Education enables the individual to develop his/her capabilities for realistic and effective intervention in the world. This development is the product of several social processes. But if the question of how this development comes about were to be asked, one unexpected answer that would be obtained is: through teaching. Teaching can be described as a way of bringing about learning; but not every way of bringing about learning in a person can be termed as teaching. What, then, is teaching? Teaching is a complex and diverse activity and what is termed as teaching may vary according to context. It may vary according to whether the teaching is in the form of showing a video, performing a dance-movement, or carrying out familiar classroom techniques like instruction, demonstration and drilling. In any of these contexts, teaching takes a different form. "Teaching", like words such as killing, satisfying, boring, and upsetting, can therefore be described as polymorphous. It is a term which lacks well defined boundaries and one which does not easily allow a formal and concise statement to be made about its meaning.

However a number of papers in educational philosophy have been devoted to the clarification of the question. Most of the philosophical essays which have discussed the question, "What is teaching?" agreed on a close relationship between teaching and learning (Kleining, 1982). Educational philosophers perceive teaching as an intentional activity. They generally support the view that teaching requires the intention to bring about learning [Hirst (1971), Passmore (1980), Kleinig (1982), Smith (1987)]. They are however careful to note that not all learning brought about in a given teaching situation would be the one intended to be induced by that particular teaching situation. To explain this point, Kleinig (1982) used the following illustration:

> As soon as we turn our attention from those conventional, institutionalised occasions and techniques of teaching, most of which would not occur without those engaging in and employing them intending to bring about learning, it becomes clear that we may and often do teach others without intending to do so. Think of how much we can be taught by someone's example - in cases where if teaching was intended it might not have been the example it was: a kindness done in response to someone's need, and without a thought for what it might teach; hypocritical acts which speak louder than words that were intended to teach; and so on (Kleinig, 1982, p 25).

An intention to bring about learning may either result in learning fully, or partly, what was intended or may lead to the learning of a completely different thing. For this reason, it is argued that it is not sufficient to regard "teaching" as an activity that requires merely the intention to bring about learning. Teaching should require both 'the intention to bring about learning' and 'learning as its outcome'. Teaching in the school context can be viewed, in this light, as an intention to bring about the learning of outcomes (or objectives) pre-determined by a given curriculum. This is the premise upon which philosophers of education have based their analysis of the concept of teaching in its generic sense.

4.4.2 Framework for analysing mathematics lessons

The different perspectives on the definition of teaching considered here suggests that no one form of teaching goes on in the primary school classroom. Every primary teacher has his/her own conception of teaching mathematics. Many teachers may view the act as merely engaging in instruction and demonstration, that is, in terms of the popular conception of the term. Some other teachers may, in addition to that, conceive the act as providing experiences and resources for learners to learn, thus conceptualising the act from the point of view of its intentions. It may be seen by several other teachers as teaching a whole class and others may perceive it in terms of teaching individuals within a class. In order to discuss these differences, I shall consider two frameworks that can be used in analysing mathematics teaching.

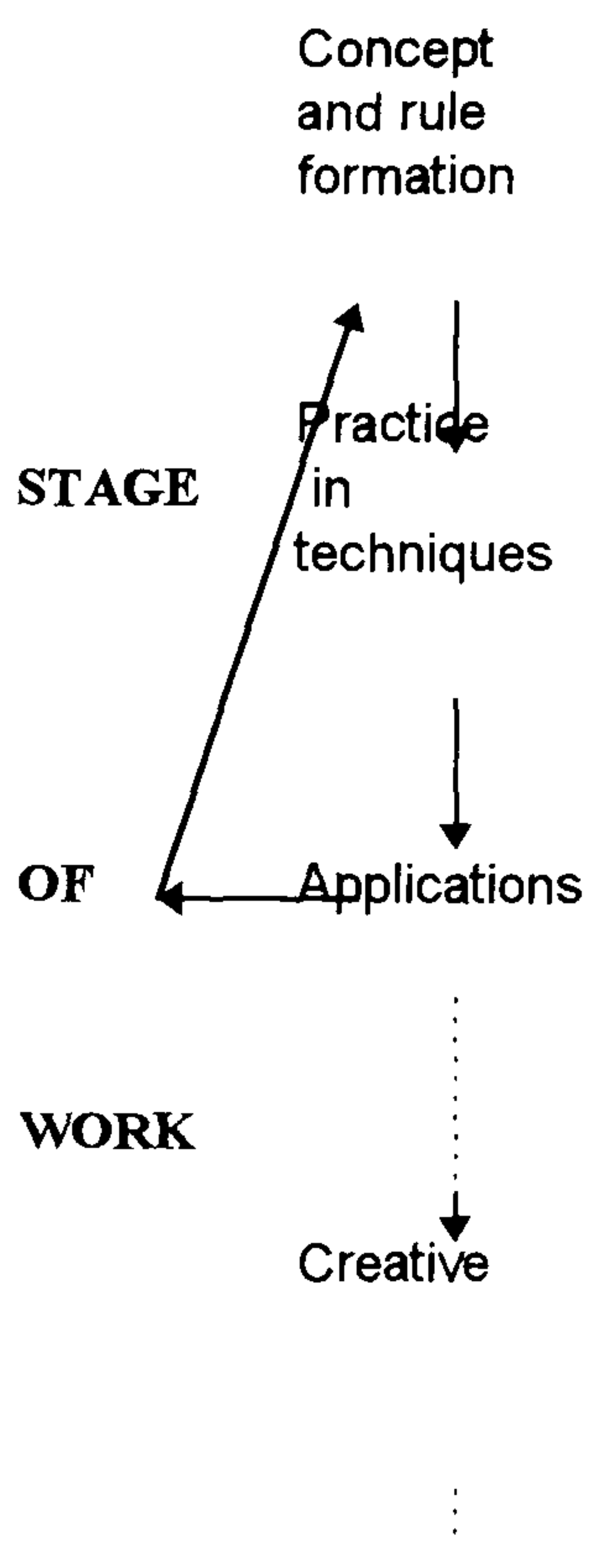
The first concerns the concept of teaching steps proposed by Henderson (1963). After analysing recorded tapes of verbal behaviours of mathematics teachers in the United States, Henderson noted that methods of teaching mathematics comprise four basic steps which he called *moves*. Adding only slightly to Henderson's original description of the moves, Jones and Bhalwankar (1990) represented the moves as:

1. Statements of Principle (SP)
   A statement of the item or knowledge to be taught.
2. Clarification of the Principle (CP)
   Through the use of examples, demonstrations, evidence of proof, discussion of sub-principles.
3. Justification of the Principle (JP)
   Establishing the truth of the principle, cross-proofs, opinion of experts, student verification, etc.
4. Application of the Principle (AP)
   Clinching the understanding of the principle through practice so that students are able to take the learned principle into other settings.

From this description, differences in mathematics teaching methods can be conceived in terms of variations in the employment of the basic moves in teaching. The variation can, on the one hand, result from the order in which a move is presented or the extent of emphasis placed on it. It will be realised form the discussion of the teaching methods in the sections that follow that, while in expository methods, the moves follow the sequence described above (i.e. SP, CP, JP and AP), the moves in the discovery teaching methods do not follow rigidly the order, even though they are all present.

The second framework for analysing mathematics teaching is that proposed by Brissenden (1980). Figure 4.5 is a representation of this frame. The frame has two dimensions, each representing the two key aspects of mathematics teaching. The first, 'the stage of work' aspect, represents the stages of mathematical activity, and the second, 'the form of organisation' aspect, represents the forms of interactions between teacher and learners that are likely to be created in lessons.

Figure 4. 5 *Brissenden's framework for analysing teaching*



	Whole Class ↔	Individual ↔	Small Group
	1	2	3
A	Teacher-led class discussion using **situations**	Textbook, worksheet, or workcard presented **situations**	Textbook, worksheet, or workcard presented **situations**
B	Teacher-led class discussion using **examples**	Textbook, worksheet, or workcard presented **exercises**	Group discussion in **exercises** (encouraged, tolerated, or discouraged)
C	In stage A or teacher **demonstration** or other subjects etc.	Individual **assignment** or **project**	Group **assignment** or **project**
D	Teacher-led **open problem-**solving	Workcard presented **open problem** or **pupil problem**	Workcard presented **open problem**, cooperative solving

TYPE OF ORGANISATION

[Note: in each box the key word for each activity is in bold type]

Source: Brissenden (1980, p 9)

It can be seen from Figure 4.5 that in the stages dimension, the frame incorporates all the stages of development of mathematical activity identified by Henderson. At Stage A, the teacher is concerned with the formation of the principle (or concept) and the rule of the principle. The teachers activities at Stage B are characterised by examples and exercises aimed at consolidating the principle introduced earlier. Stage C is the stage where the principle is applied in situations less familiar than those encountered in the other two. The situations here range from those set out in what is often termed as standard textbook problems, characterised by tasks, for which a complete procedure (usually the previously learnt principle) leading to the solution is implied to situations in other subjects or real life to which the principle can be applied.

In addition to these stages, Brissenden introduces a new stage, Stage D, which he refers to as the creative stage. He explained that this stage does not follow any sequence, it could follow or precede any of the other three stages. Stage D is an extension of the application stage and involves the creation of opportunities for open exploratory activities or pupils to engage in non-routine tasks which are different from the usual recognition, algorithmic and direct-application exercises found in textbooks (Christensen and Walther, 1986). The activities at this stage are aimed at creativity and the development of problem solving and problem posing skills. Open situations are usually presented to pupils with the hope of making them devise their own questions/answers using skills, concepts and rules they already possess.

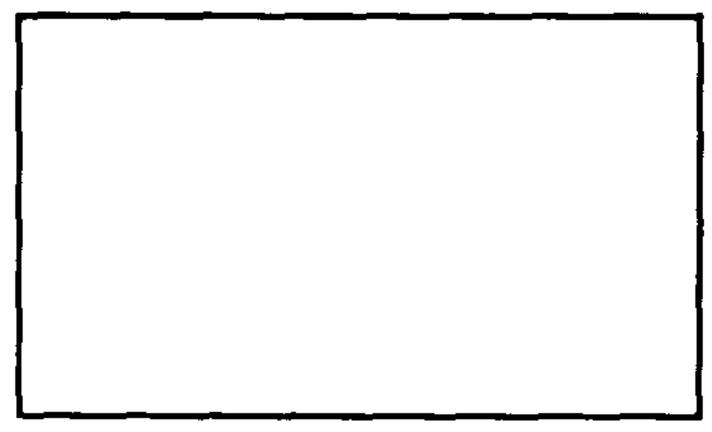
In the frame the stages of work and forms of organisation are lettered and numbered respectively, for ease of reference. On how to interpret it, Brissenden explained that

> .... a particular type of mathematics lesson can be clearly specified by listing the kinds of activity through which the lesson passes. A very common kind of lesson, for instance, consists of activity B1 (whole-class practice in techniques), followed by B2 (individual practice in techniques), or, more shortly, B1 → B2. .... A lesson may move through more than one stage, as when the teacher uses a situation which shows the rule for finding the area of triangle, applies it to several examples, and then sets an exercise. Here we have A1 → B1 → B2, or, using the corresponding keywords from the boxes in Figure 4.5, **situation → examples → exercises** (Brissenden, 1980, p 10).

The use of this framework can be illustrated by the use of the hypothetical lesson I have described in the Scenario 2.

Teaching Scenario 2 : Mr Kofie

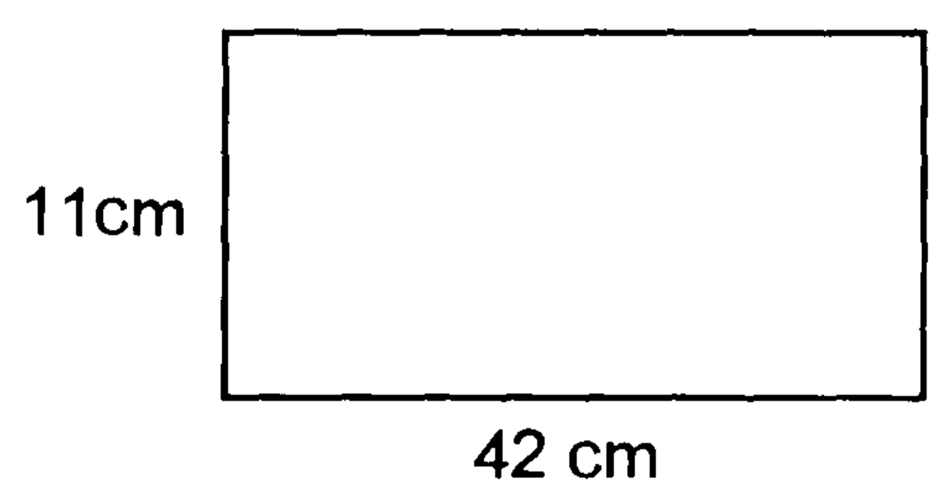
Mr Kofie teaches in a primary school in Accra, the Capital of Ghana. He has been teaching in the school for the past 15 years. Mathematics is his best among the nine subjects he teaches at this level. Mr Kofie has a favourite strategy for teaching practical applications of mathematics - such as, having pupils to calculate the perimeter of lawns or playing fields. A typical example of the format that his strategy follows can be seen in how he teaches "Perimeter" to a Primary 6 class. On the first day he begins the lesson by writing the lesson-topic "Perimeter" on the chalkboard. He draws the shape below on the chalkboard and asks pupils to identify it.

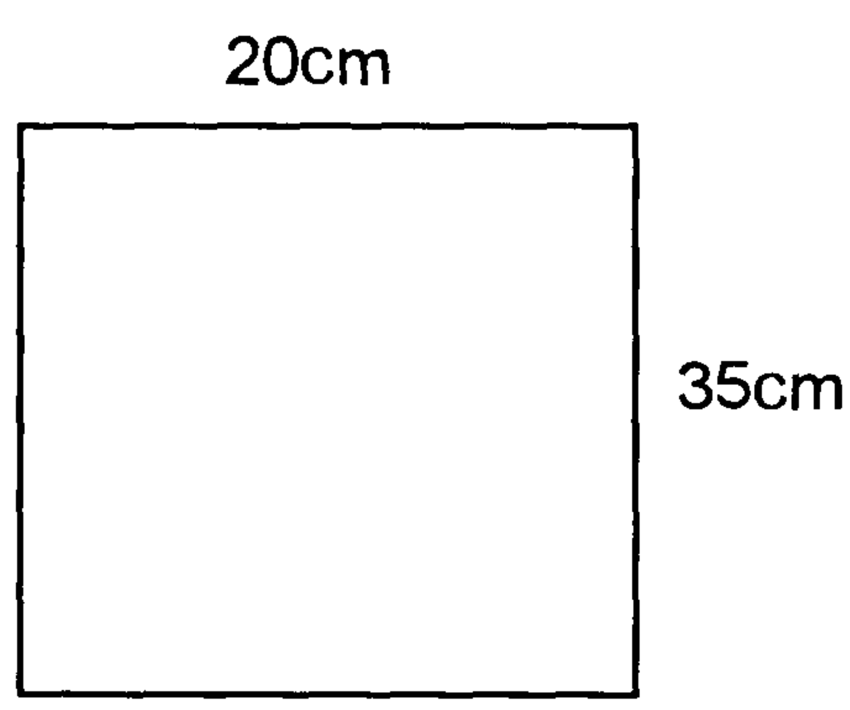


rectangle

Pupils identify the shape as a rectangle. He writes the formula, "$p = 2(l+w)$", for finding the perimeter of a rectangle on the board. As he explains all parts of the formula, Mr Kofie points out that the formula can be used to find the perimeter of the school playing field and beds in the school garden. He then asks the pupils to repeat the formula a number of times. Pupils then watched Mr Kofie as he works through some examples of finding perimeter on the chalkboard. The pupils carefully write Mr Kofie's calculation in their jotters. Pupils (usually about 3) are asked to go to the chalkboard in turn to try some more examples. Pupils are given the exercise below to do into their class exercise books.

1. Find the Perimeter of the rectangles:





2. Find the Perimeter of the rectangles with the following sides:

	Length		**Width**
(a)	7m		4.5m
(b)	21 cm	17 cm	
(c)	15.2cm		10.8 cm
(d)	48.5 m		5 m

Mr. Kofie is careful to see that the pupils follow his method and do their calculations in the exercise correctly. In the second and third lessons pupils are given more exercises, similar to the above, to do. In the succeeding lessons, Mr Kofie introduces word problems on finding perimeter of regions which are rectangular in shape. For some reason, however, Mr Kofie does not attempt to extend perimeter to shapes other than rectangles. He usually takes four 30-minutes teaching periods to complete the unit on perimeters.

Using chalkboard demonstrations Mr Kofie informed the pupils about the rule of the principle, perimeter of a rectangle, and showed them how it works. Mr Kofie works some examples with the rule, invites individual pupils to try some examples, and then sets pupils exercises to do. Using the notations in the framework, the activities described here may be represented as:

B1	→	**B2/1**	→	**B2**
(teacher-led examples with whole class)		(pupil-led examples with whole class)		(individual practice exercises at seat)

There was no evidence of a distinct Stage A activity which at this level could involve situations that will generate discussions about distance of boundaries of plane regions. Mr Kofie continued the lesson with Stage C activities. His activities at this stage were not very different from that of Stage B. The difference is that tasks presented here were "worded" into word problems. Using the framework, his Stage C activities may be represented as

C1	→	**C2**
(teacher-led demonstration - word-problem examples)		(Individual assignment - word-problem exercises)

Mr. Kofie did not include any Stage D activity in any of his four lessons.

To sum, the pattern of organisation of Mr. Kofie's lessons may be presented as **B1→B2/1 →B2 →C1 →C2.** There was no evidence of Stage A (concept and rule formation) activities as well as Stage D (creative or open investigation activities). Having considered the frameworks, I shall now describe the teaching methods.

4.4.3 Classification of teaching methods

Teaching methods may vary according to whether they are intended to induce reception learning or discovery learning. Differences in teaching methods within each category can also be conceived in terms of the meaningfulness of the learning that results from the method and this depends on the nature of tasks and the way these are presented to learners. Teaching methods that lead to learning by reception are generally described as traditional or expository teaching methods, and those that are intended to induce learning mainly through discovery are described as open or discovery teaching methods (Cohen and Manion 1987).

Jones and Bhalwankar (1990) posit that most, if not all, activities that are strategies for teaching in most developing countries fit within three categories of teaching methods namely expository, inductive and inquiry. They described the three categories of teaching methods as:

> (1) *Expository*: the teacher gives the principle under study, tells students what to do, monitors students performance as they practise the application of the principle.
> (2) *Inductive*: the teacher provides examples and non-examples of that subject under study. The principles are either presented by the teacher or developed by the learners. The teacher then monitors student performance in applying the principles.
> (3) *Inquiry*: the teacher presents problems to students to solve. Solutions of the problems are the required knowledge. The teacher then monitors students performance in applying the principles (pp.182).

In an earlier classification, Henderson (1963) described the first as 'tell-and-do methods' and the other two as 'heuristic methods'. There is an agreement between the traditional versus discovery distinctions made above and Jones and Bhalwankar's classification of the methods.

In the next two sections, the nature of, and the theoretical assumptions underlying, the two classifications of teaching are examined. The discussion will begin with a teaching scenario that illustrates the style or category. Permutations of the order of SP, CP, JP and AP that it reflects are considered. The patterns of lesson organisation involved will be examined with respect to Brissenden's framework.

4.4.4 Expository Teaching Methods

Two teaching scenarios will be referred to here to illustrate this teaching method. The first - Scenario 1 (Mrs Addo's) - was the one presented in Section 4.3.2 to illustrate the Advance Organiser model, and other - Scenario 2 (Mr Kofie's) - was the one used above in explaining Brissenden's framework. Mr Kofie commences his teaching by telling pupils the topic and the rule, that is SP (Statement of Principle). He follows this with some brief and weak CP (Clarification of Principle) by asking pupils to recite the rule. He then works through some examples on the chalkboard and gives the chance to pupils to try in turn on the chalkboard. He concludes with AP (Application of Principle) by giving exercises which he carefully supervises. It can be observed that Mr Kofie does not use teaching aids and texts and makes no obvious connections between the new concept and the pupils' previous learning experiences. Mrs Addo on the other hand makes conscious efforts to link the various aspects of her teaching of the unit in spite of the fact that she goes through the moves in the same order as Mr Kofie. She starts her lesson with revision and gradually proceeds to introduce the new principle to be learned (that is, SP). She moves to CP, uses JP to verify the formula and includes AP. The cut-out shapes she uses in addition to the chalkboard illustrations presents CP that breaks the principle into smaller parts making it easy for pupils to see its interconnections and usefulness. Her use of the table to display pupils' results for comparison presents the learning material in a logical order that will allow pupils to check the validity of the principle.

Notwithstanding the obvious differences, both methods can be described as expository. They are however methods which can be described as direct opposites of each other. Mr Kofie does not seem to have given his JP and AP steps any emphasis. Henderson (1963) points out that failure to develop the first results rather in a method that some educationists term as "drill method", and an inadequate emphasis on the second reduces the expository method to what some educationists call "lecture method". There are few educationists who will argue that Mr Kofie's approach is a useful one. With the little or no learning/teaching aids leading to weak CP and JP steps, what remains of Mr Kofie's expository method, is a drill method that leads to rote method of learning.

Mr Kofie's lesson fits what Jones and Bahlwanker (ibid), quoting Duck (1981) have called "amorphous expository" teaching. "Structured" teaching is what Duck (1981) calls the opposite of "amorphous" teaching and Mrs Addo's expository teaching is an example. Her method has a high possibility of leading to what Ausubel (1963) and other learning theorists term as "meaningful learning", which is the direct opposite of rote learning, because she is using a kind of advance organiser.

Expository teaching, if structured, provides the pupil with a cognitive structure for comprehending learning material presented through "telling" methods, reading and other media. Since it allows major concepts and propositions, when explained step by step, to integrate or interconnect into the learner's cognitive structure - what Joyce and Weil (1986) describe as "reception learning" - expository methods can bring about meaningful learning of mathematical concepts, relations and skills. Expository teaching can be combined with other methods of teaching for effective learning of higher order cognitive outcomes and complex intellectual strategies. For such systematic teaching, Rosenshine and Stevens (1986) identified the following behaviours as what most effective teachers have consistently been found to use:

- begin a lesson with a short review of previous, prerequisite learning;
- begin a lesson with a short statement of goals;
- present new material in small steps, with student practice after each step;
- give clear and detailed instructions and explanations;
- provide a high level of active practice for all students;
- ask a large number of questions, check for student understanding, and obtain responses from all students;
- guide students during initial practice;
- provide systematic feedback and corrections;
- provide explicit instruction and practice for seatwork exercises and, where necessary, monitor students during seatwork (Rosenshine and Stevens, 1986, p.377).

Mrs Addo's style of expository teaching fits the description of what constitutes systematic teaching since she used most of the teaching behaviours stated above. She began a lesson by reviewing the concept of polygons using cut-out shapes that is, circles, triangles, squares, rectangles, hexagons and octagons).

Through detailed instructions and explanations she introduces the concept in small steps and provides opportunity for student practice after each step. She asks questions and checks for student understanding. Unlike Mr Kofie's method, the learners in this method engage in active reception of new knowledge by engaging in didactic interactions with the teacher to see interconnections that exist between the new topic and what already exists in their minds.

The two forms of expository teaching method can be summarised as presented in the table below:

EXPOSITORY TEACHING METHOD	
Amorphous exposition	Structured exposition
a) new content is presented through textbook examples and exercises.	a) new content is presented through context - practical and concrete experiences.
b) content is presented in the form of rules about mathematical principles.	b) content is presented in the form of logical relationships and truths about mathematical principles.
c) the content involve mainly mathematical skills.	c) the content involve both mathematical concepts and skills.
d) new content is taught solely in whole-class work sessions.	d) new content is taught mainly in individual- or group-work sessions but with occasional whole-class work sessions.
e) teacher directs all classroom activities.	e) teacher initiates all classroom activities.
f) classroom discourse pattern is one-way, teacher to pupil (or class) and not the converse.	f) classroom discourse pattern varies, pupil to pupil, teacher to pupil (or group) and the converse,
g) pupils listen passively and submissively, and memorise rules and procedures.	g) pupils listen actively and cautiously, and assimilate rules and procedures.
h) pupils respond to teacher's questions and do exercises.	h) pupils listen to teacher and participate in classroom discourse
i) pupils are satisfied with just knowing how to carry out correct mathematical procedures.	i) pupils seek to understand the logic behind procedures they are taught.

4.4.5 Discovery Teaching Methods

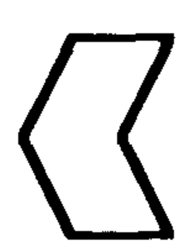
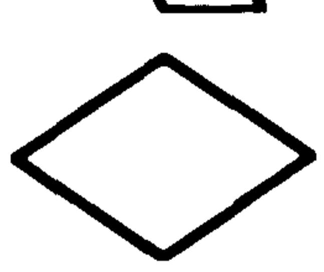
Teaching Scenarios 3 and 4 (Mrs Eshun's and Mr Boboobe's) will be referred to here to illustrate these teaching methods. The teaching scenarios are presented below:

Teaching Scenario 3 : Mrs Eshun

Mrs Eshun is a lecturer in the Mathematics and Science Division of the University College of Education at Winneba in the Central Region of Ghana. As the tutor in charge of teaching methods and the divisional co-ordinator of teaching practice, Mrs Eshun tries to organise series of demonstration lessons in a nearby school for student-teachers before they encounter their first teaching practice. The introduction to one of her demonstration lessons, in this particular case, on the teaching of perimeter, begins with giving pupils sitting in groups the opportunity to manipulate and identify various cut-out shapes by their names and properties. She then challenges each group to describe how it will determine the distance around each of the shapes. She proceeds by asking pupils to wind strips of paper round the shapes and measure these to obtain the "distance round" or "perimeter" of each shape. She then draws a triangle on the chalkboard and marks the sides 8 cm, 5 cm and 5 cm and, with questioning, makes the pupils to recognise that the perimeter is the sum of the sides. She does this with several other different shapes and writes similar exercises on the chalkboard for pupils to do in their exercise books.

The next day, Mrs Eshun asks the pupils to sort from a new set of shapes those whose sides are all of equal length. The pupils are made to measure the perimeter and the length of a side of each of the regular shapes. Mrs Eshun draws the chart below on the chalkboard and asks pupils to copy and complete it with the results of their measurements.

Regular Shapes

Measured shape (P)	Length of side (l)	Number of sides (n)	How is 'p' related to 'l' and 'n'?
	5	3	$15 = 5 \times 3$
	2	6	$12 = 2 \times 6$
	3	4	$12 = 3 \times 4$

Pupils are able to recognise the relationship $p = nl$ after studying their charts. Mrs Eshun then gives the pupils sets of rectangular shapes and leads them through a similar process, but this time looking out for the relationship between the perimeter and the length (l) and width (w) of the rectangular shape. Unsurprisingly, the pupils come out with the reaction
$p = 2(l+w)$ using a second chart.

Rectangular Shapes

Measured perimeter (P)	Length of rectangle (l)	Width of rectangle (w)	How is 'p' related to 'l' and 'n'?
A	3	2	10 = 2(3 + 2)
B	4	2	12 = 2(4 + 2)
C	5	3	16 = 2(5 + 3)

Mrs. Eshun gives the pupils some problems to solve in their exercise books. She asks the pupils to copy 8 problems from the textbook and do as homework. Mrs Eshun takes four class periods to demonstrate the concept.

Teaching Scenario 4 : Mr Boboobe

Mr Boboobe is a lecturer in mathematics at the University of Science and Technology, Kumasi, Ghana. He is often invited to give demonstration lessons at in-service courses organised by the Ghana Education services or at workshops and conferences organised by the Mathematical Association of Ghana. In spite of the fact that he works in Kumasi, a city centrally located within the country which attracts most courses and conferences, Mr Boboobe is regularly invited to give demonstration lessons because of his interest in making teachers use problem-solving methods and in ensuring pupils have the opportunity to solve problems that are related to the needs of the communities in which they live. His introduction to the topic 'perimeter' begins with giving pupils a worksheet (reproduced below) that poses a problem. He allows the pupils some time to read it silently first and asks one child to read it to the hearing of the whole group. Using 2 cm by 2 cm cardboard square cut-outs to represent the 1 m^2 concrete slabs, he briefly explains the problem.

He allowed the pupils some time to read it silently first and asks one child to read it out to the the whole group. Using 2cm by 2cm cardboard square cut-outs to represent a 2m by 2m plot, he briefly explains the problem. He asks pupils, working in groups of five, to draw the plan that will take the given number of plots (i.e. cut-out squares) and require the shortest possible length of fence. He gives each group enough cut-out squares and an A3 plane sheet of paper.

FENCING THE CLASS GARDEN

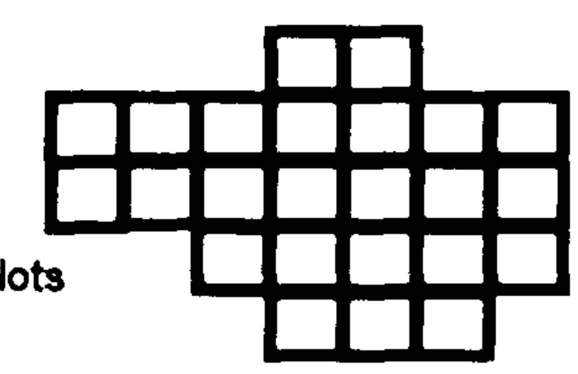
As part of their continuous assessment project work in agriculture, each of the 24 pupils in Senyokofe L.A. primary school is to grow some crops on a 2 metre by 2 metre plot in the class garden.

Before they start growing their crops on the plots in the garden they need to put a fence around the piece of land to be used by the whole class in order to keep off goats and chickens from destroying the crops.

2cm

2cm 

cardboard square cut out

a possible layout of plots 

a) What layout of the 2m by 2m plots will yield a piece of land that will require the shortest length of fence around it ?

b) What layout of the 2m by 2m plots will yield a rectangular piece of land that will require the shortest length of fence around it ?

Mr Boboobe goes round as the pupils work in their groups on the task to listen to some of their discussions. He is careful about how many clues he gives out and warns the pupils to ask questions that demand only 'Yes' or 'No' answers. He does not answer questions like "Am I right?" or "What is the answer?" No matter how long it takes, the pupils are on their own. When he finds that they are stuck he asks the question "What would happen if ...?" Mr Boboobe asks the groups to present their initial findings after the first 15 minutes. As expected, each group has just one plan in its presentation. Mr Boboobe urges them to continue to look for other possible plans by making them realise how important these are in showing whether or not a particular plan is the best. After another 10 minutes, several plans emerge from the various groups. Mr Boboobe stops the exploratory activities and asks students to report their findings after explaining that the distance round a region is called the *perimeter.* He asked each group to describe the quick-method they used in checking the perimeters or distances round the plans they made. In their description a group made an interesting observation about the relationship between the number of straight sides in a plan and the distance round it. They also observe that the lesser the number of straight-sides in the plan the shorter the distance round it. Mr Boboobe asks the class to verify the group's hypothesis. Based on the results of their verification of the group's theory, the class agrees that since the garden plots are squares the shortest perimeter fence that is possible can be obtained from a rectangular piece of land or a piece of land with four straight-sides. Mr Boboobe then asks the pupils to continue with the second part of the problem by investigating this time plans that are rectangular. He summarises the descriptions, from the various groups, of the quick-checking procedures used in verifying the perimeters of the plans they made on the chalk board as follows:

Groups 1, 4 & 5 : $l + l + w + w$
Group 2 : $l + l + w + w$ or $(l + w) \times 2$
Group 3 : $2 \times l + 2 \times w$

Mr Boboobe writes the measurements of some of the rectangular plans the pupils design on the chalkboard in a chart as shown below, and through questioning, asks the pupils to determine the perimeters using their quick-check methods.

Measurement of plot (l, w)	Length of fence around plot (p)
(24,1)	50
(12,2)	28
(8,3)	22

He varies the number of plots in the problem to 20 units and later to 30 units and asks the groups each time to find all possible plans. Satisfied that the quick-check methods realised by the pupils themselves are in fact representations of the conventional rule for finding perimeter of a rectangle, Mr Boboobe asks his pupils to take home a similar problem, try it and bring their results back to school for discussion the next day.

Mrs Eshun (in Scenario 3 above) commences her lessons on perimeter by making students manipulate the 2-dimensional shapes and by challenging them to describe how to determine the distance around the shapes. She proceeds to develop the concept of perimeter and leads the pupils to explore and discover the relationship between the perimeter and the sides of certain special shapes. The pattern of organisation she employs in her lessons may be described (with respect to Brissenden's framework) as **A3 → A1/3 → B2 → C2.** That is, group work on tasks, followed by teacher-led whole class discussion of results obtained by groups and concluded by individual practice in technique on the first day and individual homework on exercises and problems on the second day. Mrs Eshun's method can be said to involve activities at the first three stages of work in Brissenden's framework, and makes use of forms of classroom organisation which allow her to interact with the whole class, individual pupils, and groups of pupils. Unlike the explainer-teacher who uses just explanations and didactic interactions, the guide-teacher in addition to these creates opportunities through the provision of materials and directions for pupils to recognise the mathematical principle(s) or concept(s).

The major role this method ascribes to the teacher is that of a an 'inductor' or 'guide'. Unlike expository teaching, inductive teaching is largely activity oriented and mainly pupil directed. The teacher acts in accordance with the responses and progress of the learners in order to lead them to discover or learn the required concept(s).

There is much resemblance between the approach used by Mr Boboobe (in Scenario 4 above) and that of Mrs Eshun. They both first present activities which enable pupils to recognise the principle required to be learnt and generate discussions that allow the pupils to make and test hypotheses in order to clarify and justify the plausibility of the principles. Mr. Boboobe, however, creates problem situations or uses activities that require giving pupils much less guidance. Working through a problem like the one used in the scenario and investigating possible plans for the class-garden focuses the pupils' mind on the distance round the plots and hence makes them to recognise the principle that the teacher is trying to teach. The pattern of organisation Mr Boboobe employs in his lessons may be described with Brissenden's framework as **A3/2 → A1/3 → A1 → B2 → C2.** That is, pupils work in groups on problem with individuals cooperating in the groups followed by teacher-led whole class discussion of results of problem with groups and then with whole class and concluded with individual practice in techniques and homework.

In the method used by Mr Boboobe the teacher acts as a facilitator. As a facilitator the teacher's role largely involves the creation of opportunities for pupils to actively engage in tasks that enable them to inquire or investigate mathematical principles being learned. Elements of this role include providing a supportive learning environment and offering appropriate mathematical challenge. The latter requires the use of activities that are open and less structured and involve the use of pupils' own procedures or methods. Such activities are often presented in problem situations and they enable pupils to encounter learning through intellectual strategies like relationship or pattern searching and experimentation; formulation and testing conjectures about relationships; and formulation of explanations for observed rules (Jeffrey, 1978).

One consequence of the role of the teacher as a facilitator is that it denies the transmission metaphor of teaching and the corresponding reception metaphor of learning. Teachers who see their roles largely as facilitators of learning believe that the goal of teaching mathematics is not only to enable pupils to acquire knowledge of a collection of concepts and skills, but also to enable them to think for themselves and become good problem solvers and problem posers. Finally, the discovery methods make a considerably greater demand on teachers than the expository methods.

The two forms of discovery teaching method can be summarised as presented in the table below:

DISCOVERY TEACHING METHOD	
Inductive or Guided Discovery Teaching	Problem solving Teaching
a) new content is presented through context - practical and concrete experiences.	a) new content is presented through problem situations.
b) content emphasises the discovery of logical relationships and truths about mathematical principles through activity.	b) content emphasises the creation of relationships and truths about mathematical principles through problem situations.
c) the content involve both mathematical concepts and skills.	c) the content involve mainly mathematical applications.
d) teacher initiates all classroom activities.	d) pupils decide which problems to solve.
e) pupils engage actively in structured activities and discover rules about mathematical principles.	e) pupils engage actively in problem solving activities and make the own rules about mathematical principles.
f) the teacher probes for potential misconceptions in the pupils by using carefully chosen examples and non-examples.	f) teacher encourages pupils to guess and conjecture and allows them to reason things on their own rather than show them how to reach a solution.
g) teacher maintains an open classroom atmosphere which gives students freedom to ask questions and express their ideas.	g) teacher maintains a supportive classroom environment and offers appropriate mathematical challenge.

4.5 Teaching skills and changing traditional teaching skills

4.5.1 Teaching skills

"Technical skills of teaching", according to Dunkin (1987b), "are specific aspects of teaching behaviour that are considered to be particularly effective in facilitating desired learnings in students". The concept of specific teaching skills seems first to have been implemented in teacher education in a microteaching programme at Stanford University in the early 1960s. With the subsequent widespread acceptance of microteaching as a technique for training teachers, the concept of technical skills of teaching became well-known. A number of attempts have been made to classify the technical skills of teaching. One such attempt was the classification by Allen and Ryan (1969) which was used in microteaching clinic at Stanford University. This classification included stimulus variation, set induction, closure, silence and nonverbal cues, reinforcing student participation, fluency in asking questions, asking probing questions, asking higher order questions, asking divergent questions (Allen and Ryan, 1969). Other skills to become incorporated in the Stanford list were recognizing attending behavior, illustrating and use of examples, lecturing, planned repetition, and completeness of communication (Allen and Ryan 1969 p. 15).

As an indication of the widespread adoption of the concept of technical skills of teaching, other lists have since been developed and incorporated in the implemention of teacher education programmes. One influential list of teaching skills which emerged from a system for classifying teaching skills, developed by an Australian team of authors (Turney et al. 1973), comprise seven categories. These were:

(a) Motivational skills, including reinforcing student behavior, varying the stimulus, set induction, encouraging student involvement, accepting and supporting student feelings, displaying warmth and enthusiasm, and recognising and meeting students' needs.

(b) Presentation and communication skills, including explaining, dramatising, reading, using audiovisual aids, closure, using silence, encouraging student feedback, clarity, expressiveness, pacing, and planned repetition.

(c) Questioning skills, including refocusing and redirecting, probing, high-level questions, convergent and divergent questions, stimulating student initiative.

(d) Skills of small group and individual instruction, such as organising small group work, developing independent learning, counseling, encouraging cooperative activity and student to student interaction.

(e) Developing student thinking, such as fostering inquiry learning, guiding discovery, developing concepts, using simulation, role playing and gaming to stimulate thought, developing student problem solving skills, encouraging students to evaluate and make judgments, and developing critical thinking.

(f) Evaluative skills, including recognising and assessing student progress, diagnosing learning difficulties, providing remedial techniques, encouraging self-evaluation, and handling evaluative discussion.

(g) Classroom management and discipline, including recognising attending and non-attending behaviour, supervising class group work, encouraging task-oriented behaviour, giving directions, and coping with multiple issues (Turney et al., 1973).

Turney et al. (1973) provided a useful list of references relevant to each broad category of skills but pointed out that there were some difficulties in documenting evidence of the validity of the specific skills nominated. Similar selections of technical skills of teaching have been employed in microteaching and minicourse programmes in many different countries. Dunkin (1987b) argued that two criteria should be applied in judging the validity of technical skills of teaching. The first was the extent to which the specific aspect of teaching behaviour was distinct from other aspects of teaching. Observers should be able to agree on what constitutes the nature of the skill and should be able to identify it when it occurs. In his review of lists of technical skills of teaching, Dunkin (1976) found cause for optimisim that specific classroom behaviours commonly associated with teaching skills could be distinguished reliably by trained observers. However, he cautioned that there could be conceptual problems with some attempts to define teaching skills.

The other criterion was the extent to which the skills had been shown to enhance students learning. In terms of evidence that specific teaching behaviours had been found consistently associated with desired outcomes of students, Kilpatrick, (1978) observed that research had not convincingly shown that any pattern of teaching behaviour leads consistently to better learning. Dunkin concluded, in this regard, that

> ...there seems to be consensus among those who have reviewed research related to the identification of teaching skills that we have very little empirical knowledge about their nature and their effects as yet (Dunkin, 1987b).

Bearing in mind its weaknesses in affecting student learning, and the fact that the effective use of teaching skills is not an important concern of the present study, teaching skills identified for the instrument used in this study were carefully derived from previous studies on effective teaching skills (Cruickshank et al, 1979; Kyriacou, 1982; Marsh, 1987; Taylor, Christine, and Platts, 1970; and Rosenshine 1979) and modified to expose the use of discovery teaching methods.

4.5.2 Changing traditional teaching skills

The complexity of changes occurring in our societies, together with discoveries in mathematics and knowledge gained in psychology about how children learn, have led both to the scrutiny of, and a number of recommendations on, the teaching of mathematics in recent years. This is evidenced in a number of studies [Fey (1979), Ale (1981), Rosenshine and Stevens (1986), Desforges and Cockburn (1987), to mention only a few] and in documents such as "*Overview and analysis of school mathematics, grades K-12*", ([NACOME, 1975); "*Mathematics 5 to 11 : A handbook of suggestions*", (HMI, 1979); "*An Agenda for action*" (NCTM, 1980); "*Mathematics Counts*" (Cockcroft, 1982); and "*Primary schools - some Aspects of good Practice*" (DES, 1987), only to mention a few. A common feature of these studies and documents is that they generally express discontent with aspects of practices in the teaching of mathematics and propose strategies for modification or completely new approaches. Notwithstanding that research has not convincingly shown that any pattern of teaching behaviour leads consistently to better learning (Kilpatrick, 1978, Dunkin, 1987b), most curriculum innovations in the last three decades have been directed at changing teachers from using the methods of lecturing and of rote learning, which Guthrie (1990) refers to as "formalistic teaching" to the use of child-centred activity learning or discovery methods.

Though several teaching methods have been suggested for the improvement of mathematics teaching, making teachers to adopt such recommended practices in the teaching of mathematics has been a problem. The quotations below explicate the degree of teachers' inertia to these changes in the most developing countries, and Africa in particular.

> Although the revision and reorganisation of the subject matter has potentially made mathematics more meaningful, the methods of lecturing and of rote learning are still dominant. The utilisation in the elementary school of 'child-centred activity learning' and of manipulative materials is the exception rather than the rule (Jurdak, and Jacobson, 1981 p144).

> The underlying philosophy of 'modern' mathematics never took root because of the realities of African primary schools... Some modern topics remain: sets is the main example. The more significant method, however, involving activity, investigation and discovery remains foreign to the primary school classrooms of Africa. Perhaps it will come, but if it does it will be much more slowly than by prescription from a Ministry of Education or the recommendations of a teacher's guide (Wilson, 1992 p136).

The quotations are clear manifestations of how the problem is of making teachers to heed to advice on how mathematics should be taught, and how concerned mathematics educationists have been about it for decades. It is one thing making recommendations to improve aspects of the school curriculum and another implementing these recommendations. Even though the former can be accomplished within a matter of days or weeks, changes in what is actually implemented can only evolve slowly and gradually as observed, in the case of the United Kingdom, by Gillespie (1992).

Teachers are generally conservative with regard to curricular change. They have been found to be most receptive to proposals for change that fit with current classroom procedures and do not cause major disruptions (Doyle and Ponder, 1977). In most developing countries, limited resources makes the task of making the teacher respond to changes in classroom teaching methods not impossible but a very difficult one. Teachers are generally slow to respond to change because they normally find it safe to use methods that are consistent with their views or beliefs about the nature of teaching and learning. The views about the nature of mathematics and its teaching, considered earlier in this chapter, influence teachers teaching and their ability to innovate (Ernest, 1989; Thompson, 1984, 1992). That is, teachers views of the nature of mathematics teaching, the process of learning mathematics, and their conception of the nature of mathematics influence their classroom practice, and therefore can only be changed over a period of time. Teachers will not be happy to implement recommendations of an official curriculum document if the gap between their conceptions of the nature of teaching and how it is learned and the models of teaching and learning underpinning the intended curriculum document(s) is wide.

In a recent review, Rust and Dalin (1990) have looked at different authors' arguments about options that might be most appropriate in changing teachers' classroom teaching methods. One of the options recommended was an approach suggested by Guthrie, who made a case for improving what he calls "formalistic teaching", which characterise most of traditional education throughout the world.

Guthrie (1990) explained that most innovations intended to improve the teaching process place a double burden on teachers to improve their instructional skills but they expect teachers to alter their teaching methods in some fundamental manner. He argued that in areas of the world where teachers have low professional qualifications and academic backgrounds, it might be more efficient if teachers are made to concentrate on improving formalistic teaching skills rather than to shift to a radically different teaching style.

4.6 Summary

The discussion in this chapter has shown that several teaching methods and views about the nature of mathematics and how it is learned, are available to both curriculum designers and classroom teachers. It has illustrated theories that underpin the curriculum materials designed during the curriculum innovations of the 1960s and 1970s. In the previous chapter, how the curriculum materials designed in the last three decades for one educational system were adapted for others was considered. In the event of adapting these materials at the classroom level, teachers have been found to be generally conservative with regard change, and found to be most receptive to proposals for change that fit not only with their beliefs, but also with their current classroom procedures. Bearing in mind that research has not convincingly shown that any pattern of teaching behaviour leads consistently to better learning (Kilpatrick, 1978), Guthrie's (1990) suggestion for improving the teaching process in schools, particularly in developing countries, by helping teachers to improve what he calls 'formalistic teaching' or traditional expository teaching is worth noting. In countries throughout the world where teachers possess low professional skills and academic backgrounds, Rust and Dalin, (1990) emphasise that it will be more efficient to make teachers to concentrate on the use of traditional expository styles rather than to expect them to shift to a radically different teaching style.

PART III

THE METHODS AND RESULTS OF THE STUDY

CHAPTER 5

THE RESEARCH DESIGN AND METHODS

5.1 The Research Aims

The focus and the general aims of the study, discussed in Chapter 1, may now be elaborated as follows:

i. to analyse the subject matter content and teaching methods presented in the curriculum materials, and, in doing so, test whether the design of the curriculum itself contributes to the poor performance in primary mathematics in the country.

ii. to analyse the subject matter content and teaching methods presented in both the official curriculum materials (intended curriculum) and teachers' instruction (implemented curriculum) to see if

a) there is a match between what teachers believe they have taught and what they are expected to teach; and

b) the low pupils' attainment in the subject is really a reflection of teachers' inability to teach a substantial part of the content of the curriculum;

iii. to investigate if differences in teacher characteristics and organisational factors make any difference in their coverage of the content of the mathematics curriculum at the classroom level.

iv. to make recommendations on strategies that might foster the improvement, and use, of the official primary mathematics curriculum materials.

v. to consider amendments to the official primary mathematics curriculum and materials in the light of what teachers appear to do and not do.

Considering the above aims, the following specific research questions were formulated for the study:

a) Is the coverage of content in teachers' instruction different from the coverage of content recommended in the official curriculum?

b) Are the teaching methods emphasised by the teaching and learning activities in the official curriculum different from the teaching methods employed by teachers in its implementation?

c) Which teacher characteristics and organisational factors influence the extent to which teachers cover topics in the mathematics curriculum at the classroom level?

d) What is the structure, content and complexity of the current official primary mathematics curriculum, and what are its strengths and weaknesses?

e) Are the requirements of, and provisions in, the official primary mathematics curriculum coherent with the overall educational goals of basic education in Ghana?

The study began initially with the aim of finding the extent to which primary school teachers in Ghana implement recommendations in the official mathematics curriculum and the relationship between the way in which the teachers implement the recommendations and their participation in in-service education. However, it was realised that over 90 per cent of the in-service education courses[1] organised for primary teachers in the period under review were not directed towards the teaching

[1] See Chapter 2, Section 2.6.2.

of mathematics. In this light, the focus of the study was redirected and aims formulated as stated above.

5.2 The Research Design

To address the different, but complementary questions stated above, the study involved the use of different methods. The study combined mainly the survey approach and curriculum analysis. In addition to these, interviews were used to enhance the researcher's understanding of the implementation of the primary mathematics curriculum and to gather information on the various elements of the curriculum explored. These methods are discussed later in Section 5.3.

5.2.1 The district-based case study for the thesis

The term 'survey' is used in a variety of ways, but commonly refers to the collection of standardised information from a specific population, or some sample from one, usually but not necessarily by means of questionnaire or interview (Robson, 1993). A survey may be used for two major research purposes: descriptive or analytical. In the former type of survey studies, the researcher's aim is mainly to have an accurate description of what people in some target population, do and think and perhaps with what frequencies. In analytic survey studies, on the other hand, hypotheses are formulated, based on the data collected and checked against further information from the same survey. Since the aim, very often, of a survey study is to make generalisations about a relatively large section (or all) of the population, in drawing a sample for a survey, it must be ensured it is, as much as possible, typical of the population.

The Winneba District was selected as the source of schools and teachers for this study. Winneba is geographically located on the shores of a large windy bay[2] along the west coast of Africa that forms the southern border of Ghana. It lies at a distance of 50 km west of Accra, the capital of Ghana, and about 60 km east of Cape Coast, the capital of the central region.[3] The central region is one of the ten administrative regions in Ghana. The region is divided into ten administrative districts and Winneba is one of such districts. About 80% of the settlements in this district are rural settlements and this is close to the national distribution of approximately 68.7% obtained in the last national census held in 1984 (Antwi, 1992).

Like in most places in Ghana, the early schools in Winneba were established by missionary workers. The first school in the district - the Winneba Methodist Primary - was established in 1841 (Bartels, 1965) and by the close of the 1950s, the district had as many as twenty-three schools (Fianyehia, 1993). However due to the reforms[4] in education since independence the number of schools has more than trebled since 1950. Official records from the District Education office indicate that

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[2] It is claimed, in oral tradition, that the name Winneba is a corruption of a Dutch word which means "Windy Bay" or corrupted version of the English phrase, "Windy Bay". Other sources claim it was corrupted from the phrase "who-will-win the bar" a popular term used by the European Merchants when they were weighing gold bar against the goods brought by the local people of the bay during the early colonial era.

[3] There are 10 political regions in Ghana. The the map in Appendix 5.1 shows the regions. [Note: In all, there were (as at 1992 when this study began) 85 administrative districts in the ten regions].

[4] See Section 2.4

there were 82 primary schools in the 1992-1993 school year. In these schools was a total of 482 teachers (of which 15.8 per cent were untrained) teaching some 19,000 pupils in the district. The ratio of male teachers to female teachers in primary schools in the district was 55 : 45. The district had, on average, one teacher to each class, and the average class-size was 37. The summary of basic statistics of schools and teachers in the Winneba district, for the 1989/90 academic year, can be found in Table 5.1.

Table 5. 1 Basic statistics on primary education in the Winneba District[5]: Rates, ratios and indices

No. of Schools	84	Total No. of Classrooms	478	Average No of classrooms per school	5.69
Total No. of Classrooms in use	478	Total No. of Classes (streams)	504	Total No. of classes per classroom	1.01
Total No. of Classes (streams)	504	Total enrollment	18716	Average size of class	37.1
Number of Schools	84	Total Enrollment	18716	Average size of class	223
Total No. of classes	504	Total No. of teachers	482	Average No. of Teachers per class	0.96
Total No. of Teachers	482	Total No. of untrained teachers	76	% Who are Untrained	15.77
Total No. of Teachers	482	Total enrollment	18716	No. of Pupils per Teacher	38.8
Total No. of Teachers	482	Total No. of female Teachers	224	% Who are female	46.5

The Winneba district was used for this study because it had conditions that made its educational provisions typical of that of the whole country, and offered all the opportunities that were required to carry out a survey of this kind. The district, as shown by the national, regional and district indicators of educational provisions in Table 5.2, has educational provisions - number of classrooms per school, class-size, school size, and pupil-teacher ratios - which are typical of both regional and

[5] Extracted from the Educational Statistics file at the Ghana Education Service - Winneba District Directorate of Education in April 1993.

national averages[6]. It will be recollected from Chapter 2 that the presence of a substantial number of untrained teachers at the primary level is one of the reasons often adduced for teachers' inability to teach several mathematics topics, particularly the 'new math' topics. But from Table 5.2, it will be noticed that the proportion of untrained teachers in the district (15.7%) is just about half the figure recorded for both the regional and the national levels (that is, 29.7% and 33.6% respectively), and in fact one of the lowest in the country. The district can therefore be said to hold, in relative terms, a good record number of trained teachers. Since this makes the contribution of untrained teachers, if any, to the poor performance in the subject comparatively insignificant, using an all-trained-teachers' sample in the study, will not invalidate the interpretability of the results for teachers in the district.

Table 5. 2 The National, Regional and District rates, ratios and indices of educational provisions

	District rates, ratios and indices	National rates, ratios and indices	Regional rates, ratios and indices
Average number of classrooms per school	5.69	5.05	5.47
Number. of Classes per classroom	1.01	1.24	1.13
Average size of Class	37.10	27.20	30.73
Average size of School (enrollment)	223.00	173.24	190.10
Average No. of Teachers per class	0.96	1.02	1.09
% of Teachers who are Untrained	15.77	33.64	29.75
No. of Pupils per Teacher	38.80	27.09	28.10
% of Teachers who are Female	46.50	**	**

In spite of the fact that the district has a high number of trained teachers and also its educational provisions are typical of that of the whole country, the decision to use solely the Winneba district, which is also the district where the researcher

[6] The summary of basic statistics of schools and teachers in the whole country and the Central Region have been presented in tables in Appendix 5.2(a) and (b) respectively

works, for the study was urged to a large extent by the lack of funds[7] for the field work. The choice of using the cluster of schools in the Winneba District for the study was also urged, in part, by the range of methods demanded by the study. The methods included the observation and rating of teachers' classroom practice in mathematics teaching which demanded, given the short duration of the period for the study, the use of research assistants. The fact that such assistance was obtainable at no costs at the University College of Education at Winneba (UCEW)[8] made it appropriate for me to accept the appointment to become, first, a part-time lecturer, and later, a full-time lecturer, in the College's Department of Mathematics Education during the fieldwork period, from November 1991 to September 1993. The appointment, which enabled me to obtain the Ghana government's scholarship to complete this study in England, gave me the opportunity to modify the original research plans to embrace a multiple method approach that involved the use of experienced teachers in further training in UCEW as research assistants. The disadvantage was of course that the study has taken one year longer to complete than was originally envisaged.

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[7] The only fund available for the study was the scholarship grant which was paid to the University where the study was being conducted. The journey from Leeds (England) to Ghana and all the commuting in Ghana during the data collection was done with money from the researcher's salary.

[8] There was the possibility of obtaining assistance from certificated teachers who were pursuing further teacher education courses in the University College of Education at Winneba. These teachers were all trained. They had all been teaching for at least three years (else they could not have gained admission on to the diploma programme), most of them in primary schools.

5.2.2 The Sample: the Selection, Frame and Size

With regard to its educational administration, the Winneba District is divided into five circuits: Winneba, Senya, Awutu, Bontrase and Bawjiase circuits. The locations of the circuits can be seen at Appendix 5.3. The number[9] of schools and teachers in each circuit as at the 1992/93 school-year have been indicated in Table 5.3. One of the Circuit Education Officers of the district revealed, in an interview, that in April 1984, an International Agency (under the Ghana Primary School Development project) made a preliminary survey of the performance of the primary schools of the ten regions of the country including the Central Region. "This survey", the officer indicated, "placed the primary schools in each district in three categories, A, B and C, according to the performances of head teachers, teachers and pupils and certain inputs available in the schools". For the Winneba District, the number of schools in the three categories A, B and C (where A is the best), that were identified, according to this officer, were in the ratio 1 : 5 : 4.

Table 5. 3 Distribution of Primary Schools By Circuits in the Winneba District

Circuit	Number of Schools	Percentage of Schools	Number of Teachers	Percentage of Teachers
Awutu	15	18	91	19
Bontrase	18	21	89	18
Bawjiase	13	15	71	15
Senya	10	12	53	11
Winneba	28	34	178	37
TOTAL	84	100	482	100

[9] This data was obtained from the District Education Officer in charge of school statistics at Winneba.

Table 5. 4 *Distribution of Primary Schools by Circuit and by Sample*

Circuit	Schools in Circuit (a)	Schools in Sample (b)	Percentage in Circuit (c)	Percentage in Sample (d)
Awutu	15	8	18	18
Bontrase	18	10	21	22
Bawjiase	13	7	15	16
Senya	10	6	12	14
Winneba	28	13	34	30
TOTAL	84	44	100	100

Based on these categories and the proportion of schools in each circuit, sixty schools were identified for the study. In practice, forty-four schools from this number actually became involved in the study. These forty-four schools were self-selecting, in fact, they were the schools from which questionnaires were returned. The number of schools from each circuit in the sample has been indicated in Table 5.4.

Comparing the columns in Table 5.4, it will be realised that the proportion of schools from each circuit included in the study [column(d)] is nearly the same as the proportion of schools in the circuits [column(c)]. Even though these results were sheer coincidence, they show how well the selected sample is typical of the distribution of teachers in the district. Furthermore, as many as 70% of the schools involved came from sub-urban or rural areas (that is, schools outside the Winneba Circuit). This figure is very close to the national distribution of approximately 68.7% obtained in the last national census held in 1984 (Antwi, 1992). Also the sample included 4 category A schools, 25 category B and 15 category C schools.

The sample frame for this study, that is, the number of primary teachers in the district over which the results of this study could be generalised, was 379[10]. The sample-size used in the study was 138; that is, about one-third of the teachers in the Winneba District were involved in the study. But since the district chosen is typical of districts in the entire country, as indicated in the previous section, the results of the study can be taken as a fairly good representation of situations in mathematics teaching in Ghana.

5.3 The Research Methodology

5.3.1 The Instruments

As a result of the nature of questions being examined (see Section 5.1), the study demanded two complementary approaches. One is curriculum analysis and the other is measurement of coverage of content and emphasis in teaching methods. Two instruments[11] were designed to collect the information needed for the curriculum analysis and the measurement of the level of curriculum adaptation at the classroom level. One was a questionnaire for teachers, and the other was a curriculum analysis scheme. The teacher questionnaire provided two different forms of data. The first was of biographic-type and included data on teachers' sex, length of teaching experience, O'level GCE qualification in mathematics and participation in in-service education and training. The other included data on

[10] This figure is the total number of teachers indicated in Table 5.2 (i.e. 482) less 80 teachers at kindergarten level and 23 detached headteachers.

[11] Complete details of all instruments used in the study can be found in Appendix 5.4

ratings on the extent to which content was covered, and ratings on how often mathematics teaching strategies were employed, in teachers' instruction. Items were all of the closed type to facilitate scoring. The completion of aspects of the questionnaire required the observation of teachers in classroom settings. Notes were taken during the lesson observations on the teachers' classroom organisation and communication styles, and on types of learning tasks set as exercises for pupils. Three of the lessons were recorded on audio-tapes. The reason for limiting the number of recorded lessons to only three was partly because the approach to mathematics teaching observed in all classrooms conformed to a common classroom organisational style and communication pattern, and also because it was intended to be used only as an illustration of the teachers' classroom organisation and communication styles.

The curriculum analysis scheme was intended to show how adequately the requirements of crucial curriculum adaptation concerns had been met under current educational provisions of the nation, and to expose the extent to which these concerns were carefully thought about in the process of adaptation of the curriculum. The curriculum analysis scheme was used to obtain both quantitative and qualitative data on the content of, and methods of teaching, mathematics recommended in the official curriculum. The quantitative data were obtained from two sources, the official textbook and the official syllabus. Data obtained from the textbook included the number of exercises on concepts, skills and applications exercises; the number of pages covered by topics, and the number of instructions in the teacher's handbook suggesting classroom organisation under whole-class, individual and small-groups. Data obtained from the syllabus included number of statements of objectives, mathematical kernels; and counts of words associated with mathematics learning tasks- applications, concepts and skills. The qualitative data was, in the main, general background information on the coherence of the mathematics curriculum objectives to the overall aims of education of the nation, the structure and complexity of content of the mathematics curriculum, and the match between the roles ascribed to pupils and teachers by the curriculum.

5.3.2 Features of the curriculum, teacher characteristics and organisational factors measured

Two determinants of instructional content, which were used to estimate the extent of teachers' coverage of the curriculum at the classroom level, were measured by the questionnaire. One was content covered in teachers' instruction, and the other was teaching method emphasised in teachers' classroom practice. Content covered was operationalised as the time (expressed in weeks, or six 30-minutes periods) spent on teaching content in topics. The method emphasised was operationalised as the frequency with which the teacher employs teaching behaviours which are characteristic of any one of the two forms of classroom teaching methods (that is, traditional or discovery), considered in Chapter 4.

The questionnaire also measured personal characteristics of teachers and organisational factors that were considered likely to influence the amount of content covered during instruction. The personal characteristics were teacher's sex; length of teacher's teaching experience; teacher's GCE O'Level qualification in mathematics; and teacher's participation in in-service education and training. The organisational factors included teacher's class and size of teachers' class. To treat these features, characteristics and factors as variables, each has to be appropriately quantified. The composition of each variable and the way it was quantified are considered next.

1. *Content covered* (Teacher Questionnaire, Item 1: i - xxv)

Twenty-five items were structured to elicit responses along a three-point scale - a good deal of teaching, some teaching and no teaching - to indicate whether the teacher had done on topics in the official curriculum more than two weeks teaching; some, but not more than two weeks; or done no teaching at all. The items were intended to obtain information on teacher's coverage and emphasis on topics in the official primary mathematics curriculum. Teachers were made to examine topics listed from the official textbooks and to indicate by a tick on the three-point scale the extent to which they have covered each topic.

2 *Methods emphasised* (Teacher Questionnaire, Item 6: 1-32).

Thirty-two items were structured to elicit Likert-type responses along a four-point continuum from 'always' to 'never'. The items were intended to provide information on how often the primary teacher used selected teaching behaviours or teaching skills in mathematics instruction. To ensure the items (or teaching skills) in this instrument could discriminate between teachers who use discovery teaching methods and teachers who do not, the teaching skills included were those that favour these methods.

In studies such as this, questions of validity of the teaching skills to include in the instrument, as discussed in Section 4.5, are a matter of great concern. Dunkin (1976) argued that two criteria should be applied in judging the validity of technical skills of teaching. The first was the extent to which the specific aspect of teaching behaviour was distinct from other aspects of teaching. The other was the extent to which the skills had been shown to enhance students learning. The list of teaching skills included in the questionnaire used in this study was derived from previous studies on effective teaching skills (Cruickshank *et al.*, 1979; Kyriacou, 1982; Marsh, 1987; Taylor, Christine, and Platts, 1970; and Rosenshine 1979) and modified to expose the use of the discovery teaching method. In respect of the first criterion mentioned above, it was necessary for observers to agree on what constitutes the nature of the skill and to be able to identify when it occurs. To ensure this criterion was met, student-teachers who were used later as research assistants, were assisted to study carefully Item 6 of the questionnaire which was intended to determine how often teachers exhibited particular teaching behaviours in their mathematics teaching. The students actually did this exercise as part of their methods course which was being taught by the researcher.

As a preparation for this exercise, three different 30-minutes video-recorded lessons were presented to the student teachers to observe. At the end of each lesson observed, they were made to rate how often specific teacher behaviours were exhibited using the instrument. This was followed by a discussion of the ratings until consensus was reached on each item. Each student-teacher's ratings on the final video-presented lesson were correlated with the researcher's ratings to determine the inter-rater reliability. Twenty-two of the students for whom high[12] inter-rater reliability (or correlation) coefficients were recorded, were selected as assistants to administer this component of the questionnaire. This agrees with Dunkin's (1976) finding that if observers were trained, there was great likelihood that classroom behaviours commonly associated with teaching skills could be distinguished reliably. It is however important to indicate that the considerable inter-rater reliability obtained is not to deny the existence of conceptual problems in distinguishing between certain forms of teaching skills and therefore the results have to be interpreted with great caution.

3 *Teacher Sex* (Teacher Questionnaire A)

Each teacher was asked to indicate on a dichotomous scale whether he or she is a male or a female.

4. *Length of Teacher's Teaching Experience* (Teacher Questionnaire G)

Each teacher was asked to indicate the number of years he or she had been in full time teaching after training or the period which he or she had served as a teacher since his or her first appointment as a teacher

[12] Assistants selected were those whose ratings correlated with the researcher's with a correlation coefficient of at least 0.50. Coolican (1990: p63) asserts inter-rater reliability is adequate when the correlation is not low, and that this is often interpreted to mean a correlation of at least 0.5.Using this criterion, 22 assistants were selected for the observation and rating of the frequency with which teachers employ selected teaching strategies.

5 *GCE O'Level qualification in Mathematics* (Teacher Questionnaire F) Each teacher was asked to indicate his/her GCE O'Level grade in mathematics.

6 *Teacher's Class* (Teacher Questionnaire H)

Each teacher was asked to indicate the class he/she had taught from September 1991 to August 1992.

7 *Teacher's class size* (Teacher Questionnaire I)

Each teacher was asked to indicate the number of pupils in the class he or she had taught from September 1991 to August 1992.

8 *Participation in In-service Education* (Teacher Questionnaire Part II)

Each teacher was asked to indicate by a tick those in-service activities directed mainly towards the needs of primary school teachers which he or she had participated in, during the last five years.

5.3.3. Piloting and Administering the questionnaire

Ten teacher trainers who were pursuing further studies in mathematics education and science education in the School of Education, University of Leeds, were asked to complete the questionnaire, mainly to detect lack of clarity in the phrasing of the questions, and to give indication of the time needed for its completion. They observed the respondents will require between 40 to 60 minutes to complete the questionnaire. No changes were deemed necessary in the instruments. In January 1992 letters of introduction were obtained from both the GES Headquarters in Accra and the District Director of Education. GES Winneba, to visit schools and interview GES officials. The researcher met all head teachers in the Winneba District in the same month, and briefed them on the purpose of the study and craved for their cooperation in guiding teachers in the completion of the questionnaires.

In March 1992, a group of forty second year diploma students, who had carefully studied the instruments, took the questionnaires to teachers in the selected schools. Four questionnaires were sent to each school; two for the lower primary and two for the upper primary. The head teacher of each school was to decide which two classes in the lower primary and which two in the upper were to be involved. The students assisted the teachers to complete all, except item 6, of the questionnaire. These included items that elicit biographic data and teachers' content coverage.

In May 1992, the 22 research assistants mentioned above, were assigned to classes of the teachers who completed the questionnaires during their attachment[13] work in schools. The assistants stayed in each teacher's class for at least two hours per week for three weeks and observed the teacher teach at least three mathematics lessons during this period. At the end of the attachment period, the assistants rated how often they observed the teachers use the effective mathematics teaching behaviours listed as Item 6 in the questionnaire. The ratings were based on the evidence gathered during the observation period. The researcher visited several of the schools in the sample to observe the teaching of mathematics in the classrooms

[13] This is part of the student-teacher's method course which required them to work with teachers in schools for at least six weeks before their teaching practice in the third year.

and sat in lessons taught by twelve of the teachers in the sample who were observed and rated by the assistants. Notes were taken during the observation and particular attention was paid to the form of classroom organisation, the communication style, nature of language being used, and the nature of learning tasks set as exercises for pupils, to see if there had been any significant changes in what the researcher knew, on the basis of experience, was the common practice in mathematics teaching in Ghanaian primary schools. The researcher's experience as a primary teacher for three years (1975 to 1978), and as a teacher-trainer in a primary teacher training college for seven years (1981 to 1988), had made him very well aware of what constitutes the common practice in mathematics teaching in Ghanaian primary schools. To ensure there was enough supplementary data to provide adequate qualitative background on the teachers' style of instruction, three of the lessons visited were recorded on an audio-tape using a recording 'walkman' with a miniature clip-on microphone that was concealed from the pupils. This was done with the permission of the teachers who were not at all disturbed by the fact that their lessons were being recorded.

Five officials[14] of the District GES office at Winneba, and five officials in the GES, Head Office and Ministry of Education, both in Accra, were interviewed on their observations and opinions on the teaching of mathematics in primary schools and on in-service education and training programmes organised for teachers in the District. Three head teachers and ten classroom teachers were also interviewed on

[14] Names and schedules of officials of the GES district office at Winneba interviewed can be found in Appendix 5.5.

the teaching of mathematics in primary schools. The interviews provided information on the officers' opinions on the various areas explored which would enhance the researcher's understanding of the implementation of the primary mathematics curriculum.

5.3.4 Modifications made during the survey

Since time constraints and meagre financial resources would not permit the questionnaires to be administered by assistants outside the Winneba Circuit, item 6 of Part I of the questionnaire was deleted in the instrument sent to circuits outside Winneba. This was the part of the instrument which required assistants to sit in teachers' classes to rate how often the primary teachers used selected teaching behaviours in mathematics instruction. Also based on evidence gathered in the survey in the Winneba circuit, changes were effected in the Part II of the questionnaire and the entire instrument[15] was re-worded to ensure teachers completing it without any assistance had no difficulties.

5.3.5 Administering the curriculum analysis scheme

A curriculum analysis scheme was used to investigate the limitations of the curriculum, in terms of its level of complexity and relevance, and the extent to which the curriculum meets major concerns related to the cross-cultural adaptation of the curriculum. As these concerns required what Ward (1973) had described as higher level cross-cultural curriculum adaptation tasks (see Section 4.6.1), they will be referred to in this study as 'cross-cultural curriculum adaptation concerns'.

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[15] The questionnaire sent to circuits outside Winneba can be seen in Appendix 5.4 (c)

As indicated in Section 3.3.2, items in such schemes sometimes have an attached measure, for instance, rating scales, tabulations, and checklists which are used to quantify or portray the results of the analysis process. In their analysis scheme, Blum, Kragelund and Pottenger (1981) used a three-point scale to focus on decision points at which a curriculum is rejected or selected for further investigation. In similar schemes described by Leide (1977), several-point scales (including two-point, three-point, five-point and seven-point scales) were used in various studies. In the present analysis a three-point scale was used to indicate the extent to which selected concerns were carefully thought about in the adaptation process. The points in the scale included 2 -'To a great deal', 1 -'To a moderate extent' and 0 -'Not at all'.

Normally, these scales are used by a team of experienced school personnel or education officers who are mathematics educationists, and who have a good background knowledge of the Ghanaian primary school mathematics curriculum as well as what is used in other countries. In other words, to carry out an investigation of this nature, one needs not only to be an expert in the subject, but also to have a good understanding of why and how the subject is taught in other educational systems whose curricula are different from, but not necessarily better than, the one being examined. In investigations such as this one, Leide (1977) pointed out that there is no alternative to the utilisation of expert judgment as it involves evaluation of some features of the official curriculum as the accuracy of its content, the correctness and complexity of the language used, and their relevance to contemporary life. The fact that very few such experts can be found in Ghana, and that these experts work in institutions other than education offices in charge of primary education, compelled the analysis of the curriculum to be based solely on the expert judgment of the researcher. Even though the observations may be subjective, they are an attempt to bring out lapses in the curriculum adaptation process used two decades ago, which led then to the introduction of the current Ghanaian primary mathematics curriculum into schools.

The official curriculum materials were analysed with a list of cross-cultural curriculum adaptation concerns based on the decisions points (identified in Section 3.5) related to the following features of the curriculum:

a) within-level coherence of the intended curriculum;
b) the structure and complexity of the content presented by the teaching and learning activities in the curriculum materials;
c) match between teachers and pupils' expectations and the roles ascribed to them by the teaching and learning activities in the curriculum materials.

The full list of concerns considered in the analysis can be seen in Appendix 5.4 (d). Under the first category, the aims of school mathematics or the assumptions made by the curriculum developers about the mathematical needs of primary school pupils in Ghana were examined. In this part of the analysis, particular attention was given to the position of the curriculum developers on the pupils' affective needs and the relevance of the content of the curriculum to the pupils' needs. Under the second category, several characteristics of the curriculum materials were considered. These included the use of terminology and symbols, complexity of the materials, contexts in which concepts and facts are intended to be learned, advice to teachers on selection of content, and advice to teachers on meeting the differential needs of pupils. Concerns examined in the third category included forms of classroom social interactions suggested by the units in the teacher's handbooks and the roles these activities ascribed to the teacher.

5.3.6 The content analysis of the official curriculum materials

Content analysis has been defined in various ways (see Robson, 1993; Cohen and Manion, 1994). In the context of the present study however, it is perceived as involving the transformation of literal, non-quantitative documents into quantitative data (Bailey, 1978). It is a multipurpose research method developed specifically for investigating a broad spectrum of problems in which the content of communication serves as a basis of influence. The use of content analysis has gone through a number of phases. The earliest attempts at using content analysis involved *word counts*. More sophisticated approaches to content analysis are careful to identify appropriate *categories* (or concerns) and *units of analysis*, both of which will reflect the nature of the document being analysed and the purpose of the research. Categories are normally determined after initial inspection of the document and cover the main areas of content. These may include the *subject matter* - what it is about; *goals* - intentions revealed; *relevance* - to learners' needs and needs of society; *methods* - the methods used to achieve these intentions; etc. Units of analysis may include a single word, a theme, a character, a sentence and paragraph.

Content analysis proceeds by positing a universe of concerns (or categories) and seeking units of analysis which could be used to measure how a concern is treated in a given document.

Content analysis is used mainly in the field of mass communication. but the method has been employed in the recent past in exploring gender and ethnic stereotyping in textbooks. The advantage of using this method is that the data are in permanent form and hence can be subject to re-analysis, allowing reliability checks and replication studies. Nevertheless, since the documents have been written for some purpose other than for the research, it is difficult or impossible to allow for the biases or distortions that this introduces.

The syllabus, textbooks and extracts from the teacher's handbooks were subjected to the content analysis to obtain, on the one hand, estimates for the extent of coverage of the intended curriculum. On the other the content analysis provided quantitative data to support judgments that were made in the curriculum analysis. The units of analysis used to estimate the extent to which subject matter content is expected to be covered in the official curriculum were:

a) counts of exercises set in the official textbooks on concepts, skills and applications;

b) counts of pages covered by topics in the official textbooks;

c) counts of objectives stated on topics presented in the official syllabus; and

d) counts of mathematical kernels[16] that are related to each topic presented in the official syllabus.

In the case of the teaching method, units of analysis of coverage were employed in estimating the extent to which the official curriculum emphasises (or expects teachers to employ) teaching behaviours associated with teaching skills that favour the discovery teaching method. These were:

e) counts of words in the official syllabus describing processes associated with the three stages of mathematical activity- concepts development, skills development, and applications (or using and applying concepts);

f) counts of instructions in the teacher's handbook that are likely to induce classroom teaching with individuals, and small-groups, within the class, and induce classroom teaching in a whole-class setting; and

g) counts of teaching activities presented in the teacher's handbook that are likely to produce the following forms of classroom discourse patterns:- eliciting, informing, directing, and checking.

The schedule for the content analysis can be seen in Appendix 5.4 (d). Values for the first three measures of coverage of subject matter were obtained after the official curriculum materials had been carefully examined page by page by the researcher. The Ghana Mathematics Series textbooks were carefully examined and the number of pages and number of exercises assigned to each topic recorded. The exercises were examined further to determine those related to concept

[16] Kernels were taken as word or phrases that describe things that have to be learned to possess mathematical knowledge. See Section 4.2.1 for a detailed description.

development, applications and problem solving and those which did not. Values for the other two measures of content coverage (that is, syllabus objectives, and mathematical kernels, in topics), and estimates for the proportions of instructions in the teacher's handbook that are likely to induce classroom teaching with whole-class, individuals, and small-groups, were obtained through content analysis. Estimates for the proportion of teaching activities presented in the teacher's handbook that are likely to produce eliciting, informing, directing, and checking, classroom discourse patterns were obtained through lesson analysis. What was done in the content analysis and the lesson analysis are considered in Sections 5.3.6.1. and 5.3.6.2. respectively. Table 5.5 presents a summary of the aspects of the curriculum and the measures (or units) of analysis used in estimating coverage in the curriculum materials.

Table 5. 5 *Curriculum materials analysed and measures (or units) used to estimate coverage*

	Curriculum material analysed	Measure (or unit) used to estimate coverage
Content	Official textbook	a) number of exercises set on topics, and on concepts, skills and applications. b) number of pages covered by topics.
	Official syllabus	c) counts of objectives. d) counts of mathematical kernels.
Method	Teachers' handbook	e) counts of words in the official syllabus describing processes associated with the three stages of mathematical activity- concepts, skills and applications. f) instructions on the teaching activities in the teacher's handbooks suggesting the three common forms of classroom organisation - whole class, individual, and small group; g) instructions on the teaching activities in the teacher's handbooks suggesting the four common classroom-exchange types - elicit, inform, direct and checking.

5.3.6.1 The Oxford Concordance Programme

The Oxford Concordance Programme (OCP)[17] is a computer text analysis software package designed by the Oxford University Computing Service. The package has several uses including content analysis, stylistic analysis, textual editing, as well as production of full lists, indexes and concordances. To determine the values for the measures of coverage in (d) and (e) above, the whole official syllabus document was scanned onto a computer disc with an optical character recognition device. This is a device which transforms a document directly into a computer file without necessarily typing it onto the computer by the analyst. The scanner was used to transform the sixty-one-page-official-syllabus document and twenty-two pages of extracts from the teacher's handbook into a format that could be recognised by this computer text analysis software package.

The OCP produces three different forms of printouts or results - a concordance, an index, or a word list. These may also include some vocabulary statistics. Box 5.1 shows part of a concordance printout of 'the mathematical kernels related to the concept of sets' sorted from the official primary mathematics syllabus for Ghanaian schools. In the concordance, the words are listed in alphabetical order. Each word is surrounded by some words of context from the text and is accompanied by a reference to the left, in this case a line number, which

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[17]. For details about the programme, refer to Hockey S. and Martin J. (1988), *Oxford Concordance Programme, Users' Manual Version 2*, Oxford: Oxford University Computing Service.

indicates where that occurrence of the word is to be found in the text. The mathematical kernel in question, which is known in the OCP process as the *headword* or *keyword*, is printed on its own at the head of the entries for it. The headword is usually followed by a number indicating how many times the word occurs as indicated in Box 5.1.

Box 5. 1

Extract from a concordance printout

'Kernels of sets'

	disjoint 9
291	*Putting together disjoint sets of real objects*
292	*.Union of disjoint sets in pictures*
967	*form intersecting and disjoint sets*
968	*relate union of disjoint sets to operation of addition*
973	*1. Making intersecting sets: disjoint sets*
974	*2. Union of disjoint sets and addition*
	set 56
210	*Making drawings of sets, including empty set*
211	*Matching number name 'zero' with the empty set orally*
224	*3. Naming the set and matching it with a numeral*
249	*number of objects in, the union set by counting*
299	*separate a set into two subsets*
303	*Separating a set into two subsets using real objects*
304	*Separating a drawn set into two subsets*
	intersection 8
1397	*Finding point of intersection of lines*
1503	*it identify and name the point of intersection of two lines*
1504	find the points of intersection of a line and a curve
1505	*identify the line of intersection of two planes*
1511	*Leaning about Intersection and Lines of Intersection*
1514	*vertex; and using sticks to show the intersection of line segments*
1515	*.Finding the intersection of curves and line segments*

A general OCP index printout is presented in Box 5.2. The word is followed by its frequency, then a list of references (line numbers) and without context. The words in the index printout are given in descending frequency order and accompanied by their frequencies.

Box 5. 2
Extract from an index printout

Word list of The Ghana Primary Mathematics Syllabus

1	225 whole	39 mass	23 can	15
numbers	209 Operations	38 points	23 compare	15
3	182 figures	37 c	22 Estimating	15
be	155 Graphs	36 00	22 paper	15
addition	141 9	36 Addends	21 v	15
4	132 techniques	35 basic	21 value	15
Finding	106 given	32 an	20 numeral	14
ii	100 Integers	32 each	20 product	14
on	97 involving	32 money	20 read	14
sentences	83 order	31 tell	20 Union	14

In this study, the first step in the content analysis was the production of a word index, like the one in Box 5.2, of the official syllabus. Using this word index, all words which are kernels of topics presented in the syllabus were selected. For instance, in the case of the topic "sets", the words selected as kernels include set, sets, union, intersection, disjoint, and subset; and in the case of number operations, the words include addend, addition, associative, closure, commutative, distributive, division, multiplication, and operations. It will be observed that, on their own, many of the words are not mathematical kernels. That is, the words constitute parts of certain kernels but do not on their own represent things that have to be learned to possess mathematical knowledge. For example, 'points' or 'intersection' on their own are not kernels, but 'points of intersection' is. The decision to take any word as a kernel of a particular topic therefore requires an examination of the context in which the 'key word' appears. Words considered as kernels related to the topics examined can be seen in the box in Box 5.3.

Box 5. 3

Mathematical Topic	Mathematical kernels related to the topics examined
Set	disjoint, intersection, members, sets, subset, union
Numbers and numerals	cardinal, even, factors, hundreds, millions, multiples, notation, numerals, odd, ordinal, ordinals, Prime, Roman, tens, thousands.
Fractions	fractions.
Number plane and solution sets	points, number-line, number-plane, solution sets, equations, inequalities.
Integers	integers, negative, positive.
Rational numbers	rationals, decimals, percentages.
Operations on numbers and Fractions	addend, addition, associative, closure, commutative, distributive, division, multiplication, operations, properties, reciprocal, sequence, series, subtraction.
Ratio and proportion	interest, proportion, rate, ratio, scale-drawing, speed, unitary.
Geometry	angles, circles, congruent, curves, cylinders, prisms, direction, edges, faces, figures, horizontal, vertical, line, movements, parallelogram, perpendiculars, point, protractor, pyramids, quadrilaterals, rays, rectangles, shapes, segments, straight, triangles, squares, vertices symmetries.
Measurement	centimetres, circumference, height, length, metres, perimeters balance, heavy, kilograms, light, mass, amerika, capacity, litres, volumes, areas, regions, clock, hours, minutes, months, weeks, years, time
Statistics	bar, averages, blocks, chance, data, graphs, mean, mode, median

The second step in the content analysis process was, in this light, to produce a concordance, which displays a list of words together with their references and contexts for the selected words. Box 5.1 shows part of a concordance of the mathematical kernels which are related to the concept of sets, sorted from the official syllabus. The word in question (in this case 'set'), which is known in the OCP process as the keyword, is printed at the top of the entries of the concordance together with the number of times the word occurs. The concordance made it easier for words to be included only in topics in which they count as kernels. For example, in Box 5.1, the word 'intersection' on the Reference line 1505, was excluded from the kernels of sets because the context in which this 'key word' appears indicate that it is related rather to concepts in geometry. The examination of the keywords in contexts was not an easy task. Counts of kernels obtained in this way were recorded for each topic.

The next step in the content analysis process was to count words which describe processes that relate to work at the three stages of mathematical activity - concepts, skills and applications - as well as the number of exercises in the three stages. Words considered as related to the three stages can be seen in the box in Box 5.4. Though it cannot be denied that many of these words can be conveniently placed in all three stages in the box, a look at the contexts in which these words are presented indicate that they are given different emphasis in each of the stages. The classification of words presented in Box 5.4 is therefore based on the nature of contexts in which the words mainly appear in the official curriculum. That is, even though a word like 'measuring' describes a process that cuts across the three stages, it is used largely for mathematical tasks which require pupils to practise the skill of measuring length and angles using standard units, and the skill of finding equivalencies of units of measurement as well as carrying out computations on these. Counts of processes obtained in this way were recorded for each stage of mathematical activity.

Box 5. 4	
Stage of mathematical activity	**Words describing mathematical processes**
Concept development	counting classifying estimating folding matching ordering re-naming sort sorting tiling discover discovering discuss discussion explore extending guide comparing describing identifying.
Skill development	graphing drawing measuring tables techniques problems tell telling colouring colour collecting completing locating.
Applications and problem solving	environment game games puzzles rhymes riddles snap story tic-tac-toe guessing investigating predict modeling relationships.

Identifying exercises to be counted in each stage of mental activity was as difficult a task as the examination of the keywords in contexts. It involved the examination of the exercises (or learning tasks) found under each topic to see if it was intended to lead to the recall or memory of concepts, development of skills, or application and use of mathematics. It is important to point out that the task of classifying the exercises into the three stages of mathematical activity was not a straightforward one. As mathematical principles do not exist in isolation, it was not always easy to tell if a given mathematical task is intended to lead to the learning of a new mathematical principle, or to provide practice or develop skill in the use of another principle. Take for instance, exercises on numbers and numerals involving the expressing of numbers using the expanded notation - that is, expressing 4,718 as 4,000 + 700 + 10 + 8. Except the first few exercises in each unit, which were presented as examples, most of such exercises were classified as leading to skill development. Similarly, except the examples, most exercises involving the four basic arithmetic signs (+, –, ×, and ÷) were classified as leading to skill development.

5.3.6.2 Analysis of lessons presented in the teacher's handbooks

There are three aspects to the activities described in the teacher's handbooks. These are: the purpose of the activity; materials required in teaching the activity; and instructions to be followed by the teacher in teaching the activity. The instructions provide detailed guidance on specific actions to be undertaken by the teacher, tasks to be given to pupils; and responses to expect from pupils. An extract of the instructions taken from the Primary 3 teacher's handbook (CRDD, 1986, p.5-6) can be seen in Box 5.5.

Box 5. 5

Activity I

Forming intersecting sets

Ask all the members of the set of girls in the class to put their right hands on their heads. Point to individuals and ask, 'Is John a member of the set of girls? Is Mary a member of the set of girls?' (Use the names of pupils in the class) Let the girls keep their right hands on their heads.

Also ask all the members of the set of pupils who are 8 years old to put their left hands on their heads. Point to the pupils in turn and ask if they are members of this new set. For example, ask, 'Is John a member of the set of pupils who are 8 years old?'

Point to a girl who has both hands on her head. Ask, 'Is Grace a member of the set of girls?' (Yes) 'Is Grace a member of the set of pupils who are 8 years old?' (Yes) 'Is Grace a member of both sets?' (Yes) Let the class say the names of all other pupils who are members of both sets.

Ask, 'What can we say about the pupils with their right hands on their heads?' (They are members of the set of girls.) 'What can we say about the pupils with their left hands on their heads?' (They are members of the set of pupils who are 8 years old.) 'What can we say about the pupils with both hands on their heads?' (They are members of both sets, or, they are members of the set of girls who are 8 years old.)

Repeat this activity with 2 sets that are disjointed by asking, all the members of the set of girls to place their right hands on their heads while all the members of the set of boys put their left hands on their heads. Ask, 'Which pupils have both hands on their heads?' (None of the pupils) 'Are there any pupils who are members of both sets?' (No) 'What is the set of pupils who are in both sets?' (The empty set)

To determine the types of classroom-exchanges emphasised by the official curriculum, extracts of instructions in lesson activities in the teacher's handbooks were transcribed to expose the different forms of exchanges. After transcription, the instructions presented in Box 5.5 looked like the one presented in Box 5.6.

Box 5. 6

Activity I

Forming intersecting sets.

(Ask all the members of the set of girls in the class to put their right hands on their heads. Point to individuals and ask),

T. 'Is John a member of the set of girls?

P. ....

T. Is Mary a member of the set of girls?'

P. ....

(Use the names of pupils in the class)

(Let the girls keep their right hands on their heads. Also ask all the members of the set of pupils who are 8 years old to put their left hands on their heads. Point to the pupils in turn and ask if they are members of this new set. For example, ask....)

T. 'Is John a member of the set of pupils who are 8 years old?'

P. ....

(Point to a girl who has both hands on her head. Ask,...)

T. Is Grace a member of the set of girls?'

P. Yes.

T. Is Grace a member of the set of pupils who are 8 years old?'

P. Yes.

T. Is Grace a member of both sets?'

P. Yes)

(Let the class say the names of all other pupils who are members of both sets. Ask...,)

T. What can we say about the pupils with their right hands on their heads?'

P. They are members of the set of girls.

T. 'What can we say about the pupils with their left hands on their heads?'

P. They are members of the set of pupils who are 8 years old.

T. 'What can we say about the pupils with both hands on their heads?'

P. They are members of both sets, or, they are members of the set of girls who are 8 years old?.

(Repeat this activity with 2 sets that are disjointed by asking, all the members of the set of girls to place their right hands on their heads while all the members of the set of boys put their left hands on their heads. Ask....)

T. Which pupils have both hands on their heads?'

P. None of the pupils

T. 'Are there any pupils who are members of both sets?'

P. No

T. What is the set of pupils who are in both sets?'

P. The empty set.....................

The transcribed lesson activities were then analysed for the number of times the teacher is expected to initiate an exchange, the patterns of classroom exchange inherent of the activities, and the nature of pupil-responses to be elicited by the moves expected to be made by the teacher. The lesson extracts were also examined using the framework suggested by Brissendon (1980) to determine the pattern of lesson presentation, suggested by the teaching activities.

5.4 Treatment of the data on adaptation of the curriculum at the classroom level

The number of teachers making responses to items in the questionnaires have been presented in Table 5.6.

Table 5. 6 *Analysis of respondents to items in the questionnaire*

Item/variable label	Number of teachers returning questionnaires	Number of teachers completing questionnaires	Completions as % of teachers returning questionnaires
Content covered	137	137	100
Method emphasised	47	44	94
Teacher's sex	137	137	100
Teacher's class	137	127	93
Length of teacher's teaching experience	137	137	100
GCE O'level mathematics qualification	137	112	82
Size of teacher's class	137	137	100
Time allocated for mathematics teaching	47	44	94
Participation in in-service education	137	137	100

The data obtained from the teacher questionnaires were coded and quantified, and then recorded on data summary sheets, following the format required by the Statistical Package for the Social Sciences (SPSS) computer software, described by Youngman (1979) and Bryman and Cramer (1990). The data were recorded in three parts. Included in the first part were the summaries for teachers' personal, and their classroom organisational, characteristics. The second part included the data on teachers' content coverage and the third on the approach emphasised in teachers' instruction. The data were subsequently entered into the computer and the SPSS was used in the statistical analysis. But before I discuss the analysis, I shall first describe how the variables were coded and quantified and present a summary of the data obtained on the items measured.

5.4.1. The data on teacher characteristics and classroom organisational factors

Teacher Sex and class

Males were accorded a score of two (2) and females a score of one (1) on this variable. This is based on the belief, mentioned earlier in Chapter 2, that male teachers can cope with more topics in mathematics than their female counterparts, which explains the predominance of the latter in the lower classes and the other in the upper classes of the primary school. The codes "1" and "2" were also used to indicate the level (that is, either lower or upper primary) at which the teacher had taught in the 1991/92 academic year. Table 5.7 is the distribution of male and female teachers by the level at which they taught in the 1991/92 academic year.

Table 5. 7 Male and female teachers in sample by level of primary school

	female	male
Lower primary (1)		
Count	27	17
(%)	(61.4)	(38.6)
Upper primary (2)		
Count	24	69
(%)	(25.8)	(74.2)

Length of Teacher's Teaching Experience

This was the period for which the respondent had served as a teacher since his or her first appointment as a teacher. Based on the belief that teachers coming fresh from college or with shorter length of teaching experience have better knowledge of the 'new-math' content of the curriculum than their experienced counterparts, presumably because it was not taught in the latter's college days, beginning teachers were given a higher score. The scorings for this variable were: "1" teaching more than 3 years; "2" teaching 3 years or less. Table 5.8 is the distribution of teachers in the sample who were beginning teachers and those who were not.

Table 5. 8 *Beginning and others teachers in sample*

	Teachers who have been teaching for *more than 3 years*	Teacher who have been teaching for *not more than 3 years*
Count	104	33
(%)	(75.9)	(24.1)

GCE O'Level qualification in Mathematics

This referred to the GCE O'Level grade obtained in mathematics. Based on the claim that a qualification in O'Level would enhance performance in mathematics teaching, pass[18] grades in the examination were given higher scores. The variable was scored thus: (1) teachers with no qualification in O'level; and (2) teachers with qualification in O'level. Table 5.9 is the distribution of teachers in the sample who had a qualification in O'level mathematics and those who had not.

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[18] Grades 1 through 8 were all taken as pass grades. Teachers obtaining Grades 9 and those not sitting for the examination at all were classified as having no O'level qualification.

Table 5. 9 *Teachers by their mathematics o'level qualification*

	Teachers with no qualification in O'level	Teachers with qualification in O'level
Count	72	65
(%)	(52.6)	(47.4)

Participation in In-service Education and Training

This was the number of times teachers participated in in-service courses that involved activities directed mainly towards the needs of primary school teachers in the last five years. The times of participation were coded as: (1) teachers participating in not more than two in-service courses; and (2) teachers participating in more than two in-service courses. The two categories were described respectively as teachers with a good deal of participation in in-service courses and teachers without. Table 5.10 is the distribution of teachers in the sample by their participation in in-service courses

Table 5. 10 *Teachers by their participation in in-service courses*

	Teachers *without* a good deal of participation in in-service courses	Teachers *with* a good deal of participation in in-service courses
Count	122	15
%	(89.1)	(10.9)

Teacher's class size

Based on the claim that large class sizes, in light of the work load they present as a result of continuous assessment and limited school resources, hamper coverage of topics presented in the official curriculum, larger class sizes were given lower scores. The class sizes were coded as: (2) teachers who taught classes that had not more than 35 pupils; and (1) teachers who taught classes that had more than 35 pupils. Table 5.11 is the distribution of teachers in the sample by their class sizes.

Table 5. 11 Teachers by the sizes of their classes

	Teachers with class sizes not more than 35 pupils	Teachers with class sizes more than 35 pupils
Count	57	80
(%)	(41.6)	(58.4)

5.4.2 Content covered in teachers' classroom instruction

The response options on the extent to which teachers covered topics in their instruction were scored as follows: "0" no teaching on topic; "1" some teaching on topic; "2" a good deal of teaching on topic. All teachers completing the questionnaires made responses to the items measuring content coverage. The frequency distribution of teachers' response options for the twenty-five topics used in determining the extent of the teachers' coverage can be found in Table 6.4. The mean content coverage scores for the teachers were computed for each topic. To investigate whether or not there is a relationship between teachers content coverage and the extent to which topics are emphasised in the official curriculum materials. the teachers' mean content coverage scores, as will be seen in the next chapter. were compared with the results of the content analysis. The measures in the latter include number of syllabus objectives stated on topic, number of textbook pages and number of textbook exercises. To allow for the comparison, the values obtained for the estimates of coverage of the official curriculum were rated using a criterion similar to that used by Porter et al (1988). The criterion for coverage of topics in the curriculum was based on both student-teachers' ratings and the researcher's expert judgment of the amount of attention required by the topics. The measures for content coverage and the criteria for rating employed can be seen in Box 5.7.

Box 5. 7

The operational definition of "not covered", "covered", "mentioned" and "emphasised"

	Criteria for coverage			
	Not covered	*Mentioned*	*Covered*	*Emphasised*
Textbook pages covered by topic	0 pages	1 - 10 pages	11 - 40 pages	pages > 40
Textbook exercises set on topic	0 exercises	1 - 100 exercises	101 - 500 exercises	exercises > 500
Teaching objectives stated on topic	0 objectives	1 - 10 objectives	11 - 20 objectives	objectives > 20
Teachers' mean rating of coverage	teachers' mean rating 0	teachers' mean rating < 0.49	teachers' mean rating 0.50 to 1.49	teachers' mean rating ≥1.5

Furthermore, to ensure the results obtained for the teachers' mean content coverage can be compared with pupils' performance in the subject, the topics rated were grouped into five categories to match those employed in the "1992 criterion referenced tests" given to primary pupils across the country. This was simply because since the introduction of the current curriculum material, no national examinations have been conducted at the primary level to measure pupils' achievement in mathematics apart from the criterion referenced test. The five categories were labeled as: "commercial arithmetic and data handling"; "measurement concepts"; "basic number and fractional concepts"; "number operations"; and "geometric concepts". The topics grouped under each of the five categories can be seen in Box 5.8.

Box 5. 8

Category	**Topics grouped under category**
Commercial arithmetic and data handling	ratio/proportion, money, percentages, graphs, averages, interest, chance,
Measurement concepts	length, capacity, weight, area, volume, time;
Basic number and fractional concepts	fractions, sets and numbers , numbers and numerals;
Geometric concepts	geometry 1, geometry 2, angles, movement geometry
Number operations	integers, number plane/lines; rational numbers, the arithmetic operations on numbers

Composite ratings for content coverage for the various categories were calculated for each teacher and the mean scores obtained were taken as the measures of the teachers' coverage of content in each category. For instance, the teacher's mean content coverage score for the 'basic number and fractional concepts' category was obtained by computing the mean for the teacher's ratings for the topics fractions, sets and numbers , numbers and numerals. The five content coverage scores for each teacher were examined for their relationship(s) to the personal and organisational characteristics and the results are presented in the next chapter.

5.4.3 Teaching method emphasised in teachers' classroom instruction

Teachers' frequency of using teaching skills that are associated with the discovery teaching method were coded as follows: : "1 or Never" never used in instruction; "2 or Sometimes" sometimes or occasionally used in instruction, "3 or Usually/Always" often used in instruction. These ratings were used to estimate the extent to which the discovery teaching method was emphasised in teachers' instruction. In addition, the tape-recorded lessons were transcribed and analysed to provide a clear picture of the nature of teaching skills often employed by the teachers. Extracts of the transcribed tape-recorded lessons can be seen in Appendix 5.8. As in the case of the teaching activities in the teacher's handbooks, the analysis of the tape-recorded lesson transcripts was aimed at exposing the form of classroom organisation, communication style, and the nature of learning tasks set as exercises for pupils. It has to be pointed out that the researcher decided to limit the number of recorded lessons to only three for two reasons. One was because the pattern of classroom discourse employed in all the lessons observed, as can be seen in the transcription in Appendix 5.8, were the same for all lesson-types, - be it a concept development lesson where a new principle is introduced; a skill building lesson; or an application lesson. The second was due to the fact that the transcribed lessons were intended only as an illustration of what the teachers' classroom approaches generally involve. How the data on teachers' frequency of using teaching skills was treated, and how the tape-recorded lesson transcripts were analysed are considered in Sections 5.4.3.1. and 5.4.3.2 respectively.

5.4.3.1 Factor analysis of data on teachers' frequency of using selected teaching skills

The object of the factor analysis was to identify the component structures underlying the ratings of teachers' frequency of using the selected teaching skills. If such structures could be established, this would reduce the number of skills to be included in the discussion of the results. Factor analysis may be regarded as a group of techniques which aim at condensing a larger number of variables into a smaller number of basic factors. Factors obtained in this way are therefore constructs, hypothetical variables that reflect the variances shared by the research instrument (in this case a questionnaire), items and scales and responses to them (Kerlinger and Pedhazur, 1973). Factors are usually derived from the intercorrelations among variables. No factors can emerge if the correlations among the set of variables are zero or near zero. If, on the other hand, they are substantially correlated, one or more factors can emerge. Since the mathematics teaching skills which were observed were scored in favour of discovery teaching methods, the factors, if established, could provide a classification of teaching skills used by teachers who employ these methods. Subjecting the data to factor analysis would aid in conceptualising the classifications if the underlying factors were there. To examine the factorial structure underlying the mathematics teaching skills used by the teachers, a component analysis was run for the ratings of the teachers' frequency of using the selected teaching skills.

Using Kaiser's criterion (see Child (1990)), factors with eigenvalues equal to or greater than unity were first extracted; this yielded twelve factors. But based on the recommendations of Child (1990) and Norusis (1992), a factor *scree* test was carried out and the optimum number of factors was found to be five. Thus the first five factors had eigenvalues of 4.29, 3.40, 2.41, 2.37, and 2.18 respectively and these were selected. The significant factor loadings, yielded by the unrotated initial factor solution, for the five factors on the various teaching-skill items, can be found in a table presented in Appendix 5.6. The factors accounted for 48.9 per cent of the total variance (14.3, 11.3, 8.0, 7.9, and 7.3 per cent, respectively). Factor loadings whose absolute values were at least 0.4 were considered as significant (Child, 1990), and items with such loadings were used in the interpretation of the factors.

The teaching skills in the five factors were compared with the classification of teaching skills suggested by Turney et al (1973) and were found to belong to the following categories:

factor I - 'motivational skills, small group and individual instruction skills and skills required in developing pupils' thinking';

factor II - 'communication skills',

factor III - 'presentation skills;

factor IV and V - 'evaluation and learning/teaching resources management skills'.

As these skills have already been considered in Section 4.5.1, they will not be discussed any further here. The teaching skills loading on these factors, and how often the teaching skills of each factor were used by the teachers, are considered in the next chapter.

Finally, the composite scores of the items loading on each of the factors (or categories of teaching skills) obtained from the analysis, were calculated. These composite scores were taken as the ratings of teachers' frequency of using categories of teaching skills, considered by the researcher as important in increasing the chances of the pupils' discovery. The proportions of teachers who attempted to use teaching skills belonging to each factor were obtained. These proportions were used in supporting arguments on the extent of teachers' use of the discovery teaching method. Also, the composite mean ratings of teachers' frequency of using teaching skills under the four factors, were compared with their mean content coverage ratings (Section 5.4.2) to investigate if there any relationship between the teachers' use of skills of the discovery teaching method and content actually covered in their instruction.

5.4.3.2 Analysis of the tape-recorded lesson transcripts

To examine the classroom discourse patterns that characterise the teaching method used by the teachers, the transcribed tape-recorded lessons were analysed for the number of times the teachers initiated exchanges in their lesson, the types of exchange patterns these were, and the nature of pupil-responses elicited by the moves made by the teachers.

Box 5. 9

LESSON 1

School : Anglican Primary, Winneba. **Class:** P.6. **Class-size:** **Duration of lesson:** 30 mins.
Lesson topic: Multiplication of fractions (*The tape started five minutes after the lesson had begun*).

No. & Type	Initiation move	Response move	Feedback move
	(The figure had been drawn on the chalkboard. The teacher had told the pupils the plane sheet of paper he was holding could be folded to get the parts shaded on the board. The lesson continued...)		
1. T^*_e	T: Eh? Is a fraction, except what?	Ps : /////////	
2. T_e	T : So when you have a whole number, a paper like this (*raising the sheet in his hands*), is what? A whole number. And therefore it can be divided into how many parts?	C :	
3. T_e	T :Eh? It can be divided into how many parts? Eh? Eh? Eh?	P1 : four P2 : three P3 : different parts P5 : /////	T : T: If you know raise your hand.
4. T_e	T : It can be ..... Yes?	P2 : four parts P4 : three parts P1 : five P5 : one P6 : ten P7 : thirteen P8 : eighteen	T : Ehe, who else, ... Yes? T : Three. Ehe, yes? T : ehe? T : : ////// The thing is one whole part. If one part is what we require, do we have to divide again? T : Yes T : Mhm T : Yes
19.T_d	T : I want someone to use the chalk to shade another position, two out of the three we divided it, ... two out of the three? (*Teacher gives chalk to pupil*)	P9: *Drew a rectangle* C_{rt}: *(pupils clapped the praise rhythm -* taa taa ta ta taa)	T :Good, clap for her ... You see this time, Florence, she is trying to challenge you.
22.T_e	T :Hei, Akos, tell us the meaning of this *(i.e. the fraction 3/4 written on board)*?	P_{ak}: Because we have 3, we divide by 4.	T:The explanation is not coming properly ... Eh..m, Edem, help her.

[*References in square brackets refer to specific classroom exchanges taken from the transcripts. For example, [L2: 4 - 6] refers to Lesson 2, exchange numbers 4,5 and 6. Full details of conventions used can be found in Appendix 5.7. In the above extract, -

Px (where x is a letter) → a pupil with the initial x who was called by name by the teacher
T → teacher
C → class (or a large number of pupils) making a response
C_{rl} → class making a real response; ie. requiring thought and decision]

In Box 5.9 is an extract from one of the transcribed tape-recorded lessons. The transcription was laid out in columns to expose the common types of classroom exchanges which Sinclair and Coulthard (1975) described as 'moves'. They were analysed in terms of the three common moves in classroom exchanges (that is, 'initiation'- (I), 'response'- (R), and 'feedback'- (F) (see Section 3.4.4)).

Messenger (1991) observed one weakness in Sinclair and Coulthard's system for analysing discourse, especially when applied to Mathematics lessons. This she explained was that it fails to draw a distinction between pupils' responses which require thought or decisions and those which do not. She identified three types of pupils' responses which she described as echo, routine and real, of which she suggested echo and routine responses do not require thought. Messenger (op cit.) described the three types of responses as

> (i) Echo - here the teacher requires the class to echo a word or phrase, or to repeat a response supplied by an individual pupil.
> (ii) Routine responses - this includes responses to non-genuine checks of understanding or agreeing with a teacher's statement. ...
> (iii) Real responses - requiring thought, understanding, decisions etc. (p.53).

The two units of analysis considered above– that is, exchange patterns and pupil-responses elicited by teachers' moves– were employed in analysing the transcripts of the three tape-recorded lessons. The number of times the different classroom exchange patterns were used in each lesson were determined. Furthermore, for each lesson transcript, the pupils' responses were tabulated according to whether they were judged to belong to echo, routine and real responses and whether they were given by an individual pupil, pupils speaking simultaneously or pupils speaking in chorus. There was no statistical analysis of the data obtained from the lesson transcripts analysis. This was because, as indicated above, the latter was intended to be used only as an illustration of the teachers' styles of classroom communication.

5.5 Summary: The data and how it is related to the relationships explored

The nature of the data obtained and the relationships they were used to investigate have been summarised in Figure 5.1. The data in (a) in the figure, obtained as a result of an analysis of the official mathematics curriculum, was in the form of ratings of the extent of match between the overall intentions of the educational system and the intentions of the official mathematics curriculum. The data in (b), obtained by the content analysis of the official mathematics curriculum, were presented in terms of such estimates of coverage as frequencies of textbook pages, textbook exercises and syllabus objectives. The remaining data were mean content coverage ratings (i.e. (c) in the figure), and summaries for responses on teacher characteristics and classroom organisational factors, from the questionnaires.

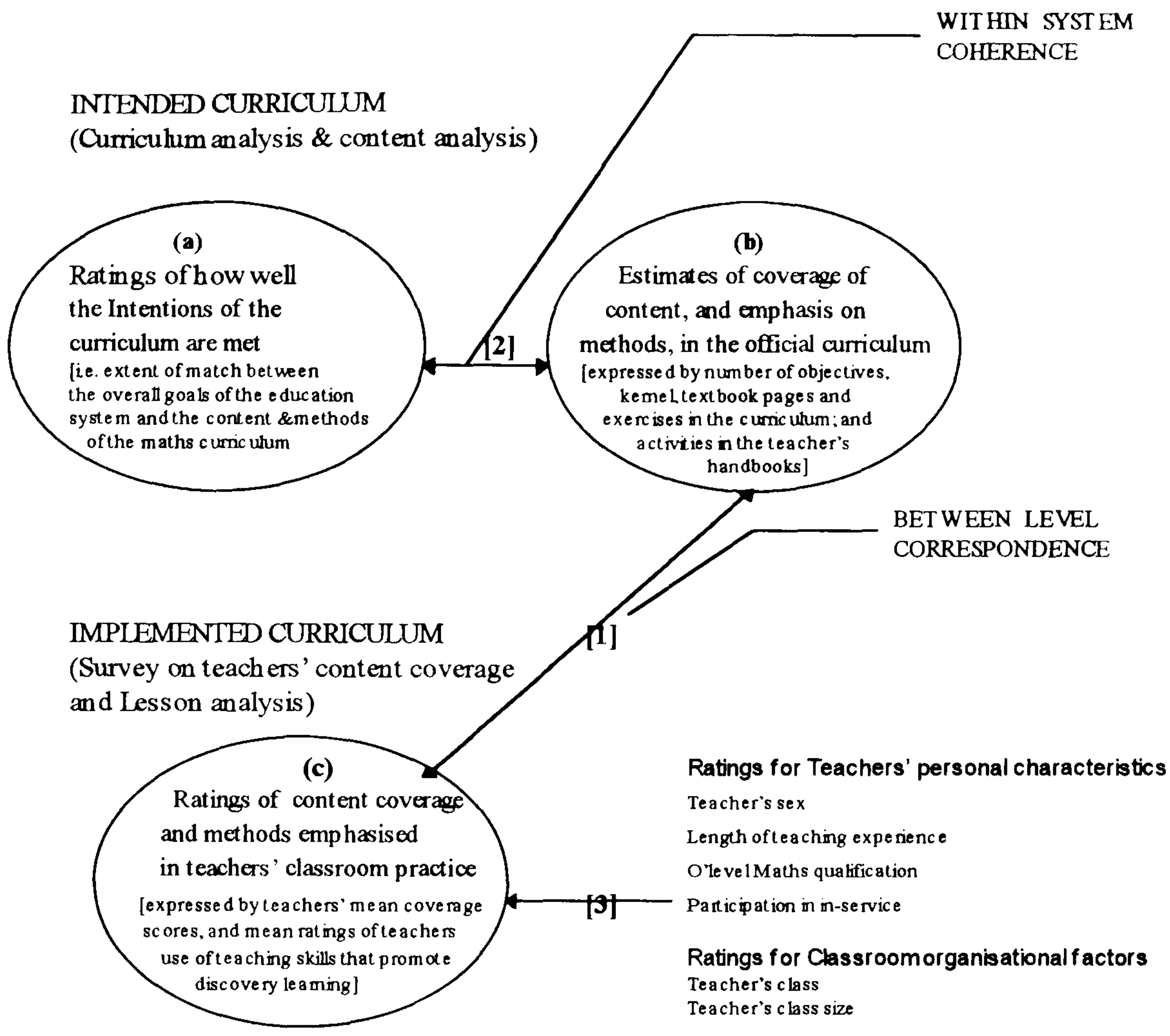


Figure 5. 1 Summary of the data and research questions explored

The data obtained were used to examine the three relationships numbered 1, 2, and 3 in the figure. The first, (1), concerns the adaptation of the curriculum at the classroom level, that is, the correspondence between the intended and implemented curricula; the second, (2), concerns the within level coherence of the curriculum; and the last, (3), concerns the influence of teacher characteristics and organisational factors on teachers' content coverage. The detailed results of the investigation are presented in the next two chapters.

CHAPTER 6

PRESENTATION AND ANALYSIS OF THE DATA ON THE ADAPTATION OF THE PRIMARY MATHEMATICS CURRICULUM AT THE CLASSROOM LEVEL

6.1 Introduction

In this chapter, the data on the adaptation of the curriculum at the classroom level are presented and analysed. The presentation is done in three parts. The first considers the adaptation, at the classroom level, of the subject matter content of the curriculum. This includes the data on the extent of coverage of content presented in the official curriculum as well as the data on the content covered in teachers' actual instruction. The results presented on the two elements of content coverage are compared to establish if they differ. In the second part of this chapter, the adaptation, at the classroom level, of the method(s) of delivering the curriculum are examined. The data involved here include ratings obtained on teachers' use of teaching skills that are likely to induce the discovery teaching method and the forms of classroom organisation and exchange-patterns employed in teachers' instruction. In the final part of this chapter, teachers' mean content coverage scores are presented and analysed according to selected teacher characteristics and organisational factors which are claimed to influence teachers' content coverage. The selected teacher characteristics are sex, length of teaching experience, O'level qualification in mathematics, and participation in in-service education; and organisational factors considered include teachers' class and teachers' class size.

6.2 *The adaptation of the subject matter content of the curriculum at the classroom level*

The adaptation of the subject matter content of the primary mathematics curriculum at the classroom level has been operationalised in terms of differences between 'coverage of the content recommended in the official curriculum' and 'coverage of the content actually presented in teachers' instruction'. In order to determine the adaptation of the subject matter content of the curriculum, the presentation and analysis of the data in this section will be carried out in the follow sequence

- coverage of subject matter content recommended in the official curriculum;
- coverage of subject matter content in teachers' actual teaching
- the adaptation of the subject matter content of the curriculum at the classroom level.

6.2.1 Coverage of the subject matter content recommended in the official curriculum

It will be observed from Table 5.5, in the previous chapter, that the data on the extent of coverage of the content presented in the official curriculum were obtained using five measures of content coverage- textbook length (or pages), textbook exercises, counts of mathematical kernels, teaching objectives stated on topics, and words associated with applications-related, concepts-related and skills-related learning tasks. Table 6.1 provides summaries of the estimates of coverage of the official curriculum obtained with these measures.

Table 6. 1 *Estimates of coverage of content presented in topics in the official curriculum*

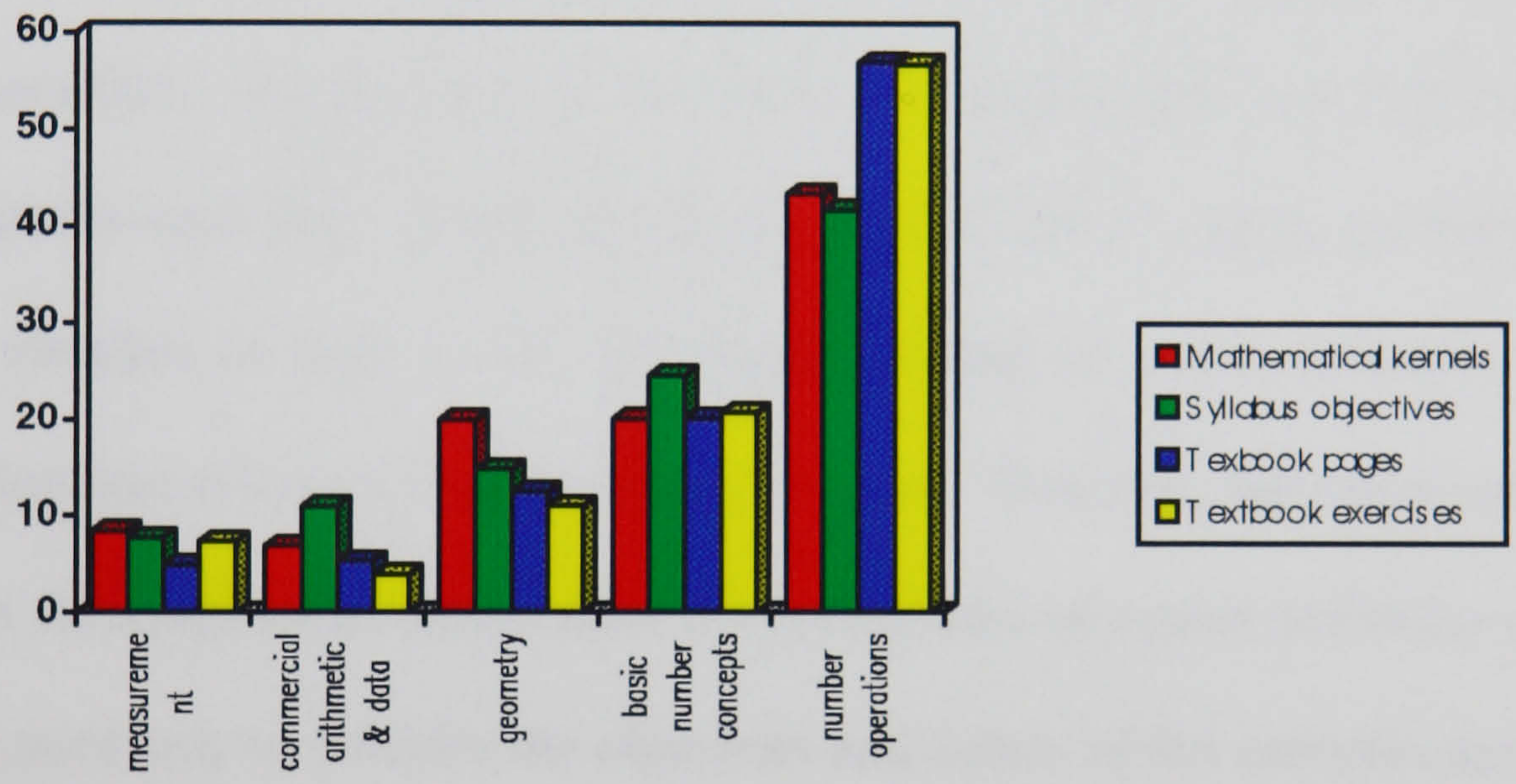
TOPICS	Number of exercises[a] set in textbooks	Number of pages covered in textbooks	Number of objectives counted in syllabus	Number of kernels counted in syllabus
Averages - mean, median, mode	32	4	3	27
Chance (or probability)	64	2	1	6
Graphs and tabular data	93	2	8	41
Movement (or transformation) geometry	105	4	4	b
Descriptive geometry- points, lines, 2&3-D figs	121	10	2	113
Angles - measurements and applications	131	7	4	107
Descriptive geometry- points, lines and 2-D figs	365	39	22	89
Measurement and applications	392	30	20	168
Sets and numbers	134	42	29	179
Fraction	304	34	15	95
Numbers and numerals	603	53	47	241
Algebra and numbers (number sentences ...	183	13	10	c
Rational numbers	123	17	15	81
Integers and the four basic operations	433	11	9	48
Fractions and the four arithmetic operations	1013	63	46	c
Whole numbers and the four arithmetic operations	3110	324	108	574[d]

[a] This excludes the number of exercises in the textbooks for Years 1 and 2, since a substantial part of the exercises at this level involves non-written tasks].
[b] The key words for this topic, including line, plane, point, shapes, etc., were difficult to distinguish from those of 2D and 3D geometry and were therefore counted under the latter.]
[c] The key words for this topic were difficult to distinguish from those of operations with whole numbers. It was more convenient to combine the kernels of this topic with kernels of operations with whole numbers.
[d] This includes also kernels of operations with fractions.

It will be recalled that topics which were considered in determining the extent of coverage of topics in the official curriculum were further grouped into five categories (presented in Box 5.8). This was mainly to ensure the results obtained on the coverage of content presented in topics were comparable to results on pupils' performance in the subject. The estimates of content coverage of the official curriculum obtained with respect to these topic categories, which can be seen in Table 6.2 in Appendix 6.1 (a), have been presented in Figure 6.1.

At a glance, the figure shows that traditional arithmetic topics under numbers and fractions, and the operations on these, which include 'new math' topics like sets, algebra and points in the number plane, integers, rational numbers, and chance cover well over 60 per cent of the content of the textbooks. The remaining content is apportioned, almost in similar proportions, to topics in the rest of the categories including geometry, measurement and commercial arithmetic and data handling.

Figure 6. 1 *Coverage of the five topic categories in the official curriculum*



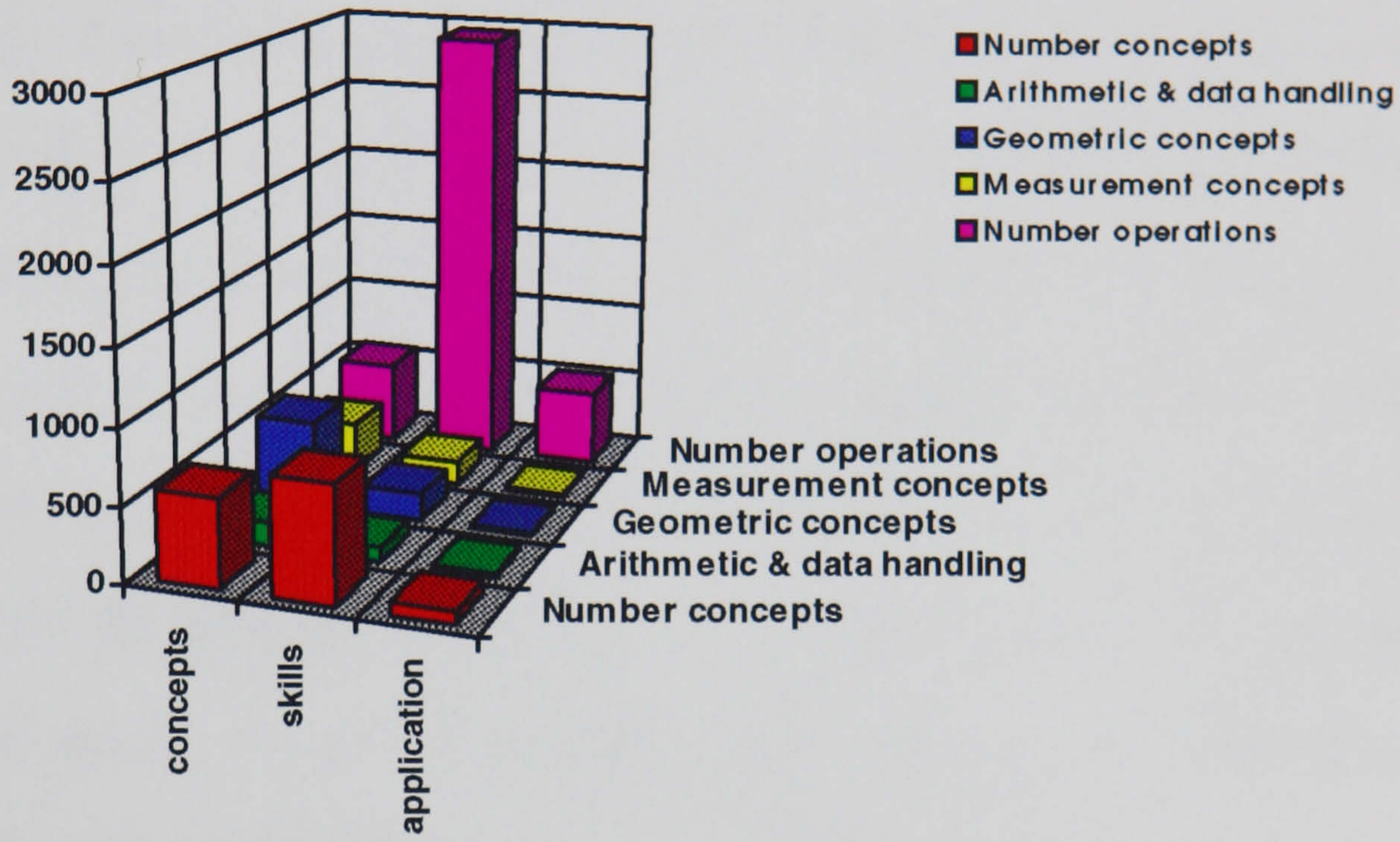
It will be recognised that with respect to all four units of analysis of content coverage, number operations is the most emphasised. The learning tasks included in the textbooks on topics in this category are mainly tasks that involve paper and pencil computation presented in isolation (that is, not in context). Number operations cover a substantial proportion of the curriculum. This area of content covers a little above 40 per cent when considered in terms of syllabus objectives and as high as 57 per cent when measured by the number of textbook exercises.

Topics in basic number concepts too receive a considerable amount of coverage. They cover about 20 per cent of the content of the curriculum. This implies number operations and basic number concepts together cover about 70 per cent of the content presented. The figure also illustrates how topics that involve concepts in measurement, geometry, and commercial arithmetic and data handling, receive modest attention in the curriculum.

The textbook exercises (or learning tasks) were further examined to see whether they are intended to lead to the recall and memory of concepts, development of algorithms and skills in using these, or application and use of mathematics. As indicated in the previous chapter, this was not an easy and straightforward task. It was not always easy to tell if a given mathematical task was intended to lead to the conceptual learning of a new principle, or to the development of a new computational technique. However, this observation did not affect the conclusions drawn since the proportions of mental activities so obtained were used only to describe the objectives and nature of the exercises prescribed by the official curriculum. The results obtained on this have been presented in Figure 6.2. It has to be mentioned that the exercises considered were those whose tasks were judged as requiring written work from pupils. The exercises in the textbooks for Years 1 and 2 were therefore not included, since a substantial part of the exercises at these levels involves non-written tasks.

The exercises found in the textbooks can be described as tasks for concept development and algorithmic or skill practice. The graph in Figure 6.2 is an illustration of the data presented in Appendix 6.1. The columns clearly indicate how the textbooks emphasise number computations and development of skills involving these. Furthermore it shows how skill and application exercises on topics in

Figure 6. 2 Coverage of the official curriculum by textbook exercises on concept development, computational skills and applications



measurement, geometry, and commercial arithmetic and data handling, receive comparatively little attention in the curriculum. Besides, the learning tasks in these topic categories were not organised in a manner that would provide context for applying and enhancing pupils' knowledge of number operations and basic number concepts. In other words, they are not integrated with the topics presented in number operations and basic number concepts.

6.2.2 Coverage of subject matter content in teachers' actual teaching

The teachers' response options for coverage of the twenty-five topics in their actual classroom teaching in the 1991 to 1992 school year were used in determining the extent of their coverage of content. Table 6.2 is the summary of the teachers' responses on the various topics. It is worth noting the responses made in the table to the "new maths" topics which include sets, geometry, algebra and points in the number plane, integers, rational numbers, and chance. Topics in sets were the most popular "new maths" topics, and as many as 88.1% of the teachers emphasised their teaching. Topics dealing with integers and rational numbers were also popular with 65.5% and 61% of the teachers indicating they emphasised them in their teaching. Topics in geometry were not as popular as integers, nor were topics in algebra and points in the number plane. The least taught among the new maths topics were those dealing with chance (or probability) which as many as 76.6% of the respondents declared they did not teach. These results indicate that with the exception of chance, the new maths topics in the curriculum are covered or emphasised by at least 60% of the teachers in the sample.

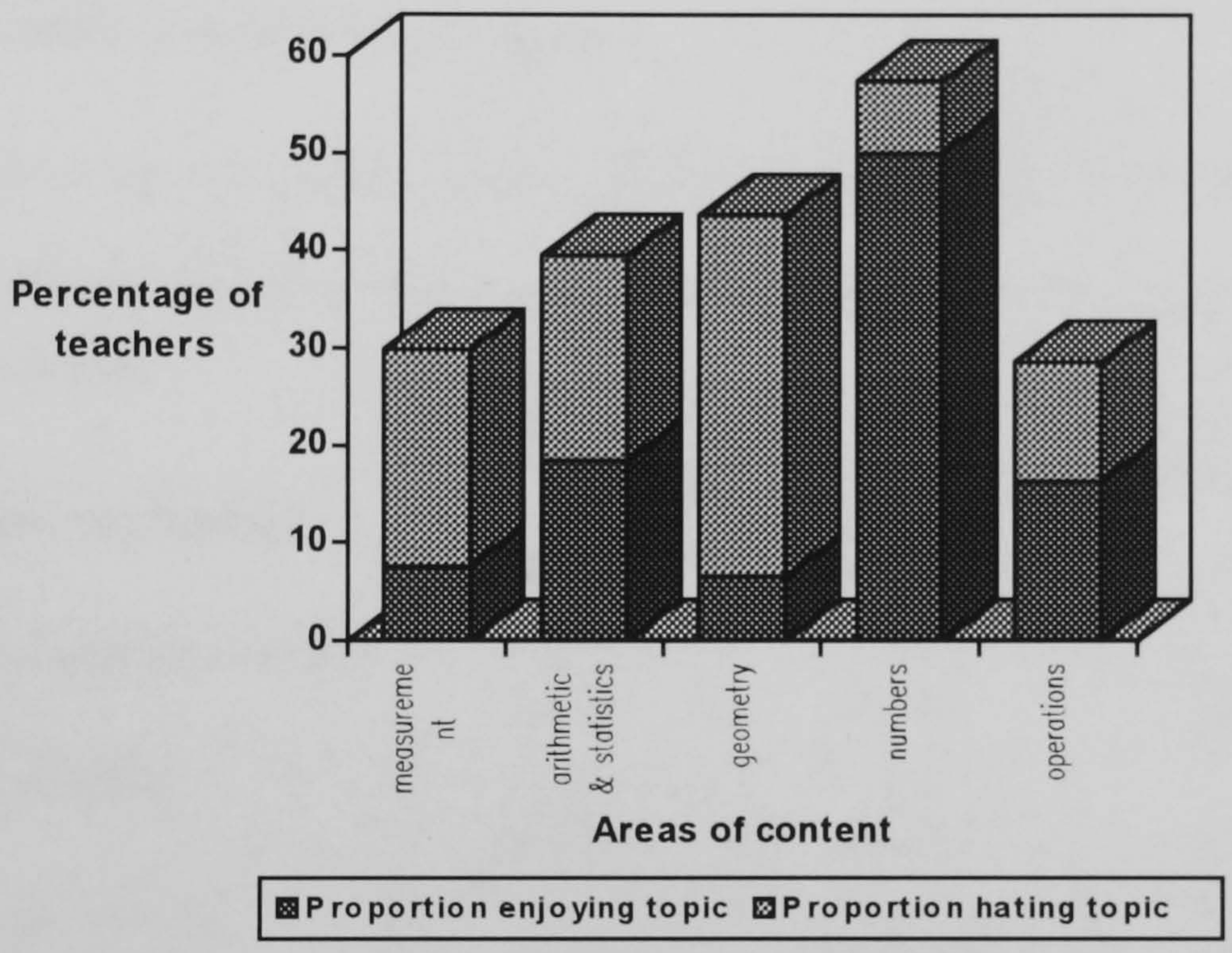
Table 6. 2 Teachers' self-ratings of coverage of topics presented in their teaching in the 1991 to 1992 school year

TOPIC	NUMBER* OF TEACHERS		
	Concept not treated	Concept treated with some emphasis	Concept treated with a good deal of emphasis
Averages - mean, median, mode	20 (27.0%)	22 (29.7%)	32 (43.2%)
Chance (or probability)	33 (76.7%)	7 (16.3%)	3 (7.0%)
Graphs and tabular data	34 (41.5%)	21 (25.6%)	27 (32.9%)
Movement (or transformation) geometry	36 (55.4%)	16 (24.6%)	13 (20.0%)
Descriptive geometry (points, lines, 2D & 3D figures	36 (41.4%)	34 (39.1%)	17 (19.5%)
Angles - measurements and applications	18 (24.0%)	32 (42.7%)	25 (33.3%)
Descriptive geometry (points, lines & 2-D figures	12 (11.7%)	44 (42.7%)	47 (45.6%)
Measurements and applications	28 (22.0%)	74 (58.3%)	25 (19.7%)
Sets and numbers	3 (2.2%)	13 (9.7%)	118 (88.1%)
Fraction	4 (4.3%)	26 (28.3%)	62 (67.4%)
Numbers and numerals	1 (.8%)	14 (11.4%)	108 (87.8%)
Algebra and numbers (number sentences, ...)	32 (36.8%)	25 (28.7%)	30 (34.5%)
Rational numbers	13 (15.5%)	31 (36.9%)	40 (47.6%)
Integers and the four basic operations	10 (11.6%)	13 (15.1%)	63 (73.3%)
Fractions and the four arithmetic operations	9 (11.4%)	28 (35.4%)	42 (53.2%)
Whole numbers & the 4 arithmetic operations	2 (1.5%)	65 (48.5%)	67 (50.0%)

[*The counts recorded in the table exclude the numbers of teachers indicating the topic as not included in the curriculum of the class he or she taught. Because some of the teachers were teaching in classes in which certain curriculum elements were not taught, the percentages of teachers making responses on each topic do not always total 100.]

Further evidence in support of the observation that teaching the "new maths" topics had not been a problem was obtained from teachers' responses to an item in the questionnaire which asked them to indicate (a) the subjects they 'enjoyed' teaching most and (b) the subjects they 'hated' teaching most. The results[1] of the teachers' responses are presented in Figure 6.3. [In making such judgments, it is natural for some of the respondents to remain indifferent. Because some of the teachers assumed an indifferent stance on these questions, the percentages of teachers making responses on each do not total 100].

Figure 6. 3 *Teachers' choice of topics they 'enjoyed' and 'hated' teaching*



Topics in basic number concepts and number operations (which include most of the new content that came with the Ghana Mathematics Series schemes like disjoint, intersection, sets, subset, union, solution sets, inequalities, integers, rational numbers, negative, addend, associative, closure, commutative, distributive, operations, to mention only but a few), were indicated as hated by just 7.4 per cent

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[1] See Appendix 6.2 (a) and (b) for the detailed summary of the responses on teachers' choice of topics they 'enjoyed' and 'hated' teaching.

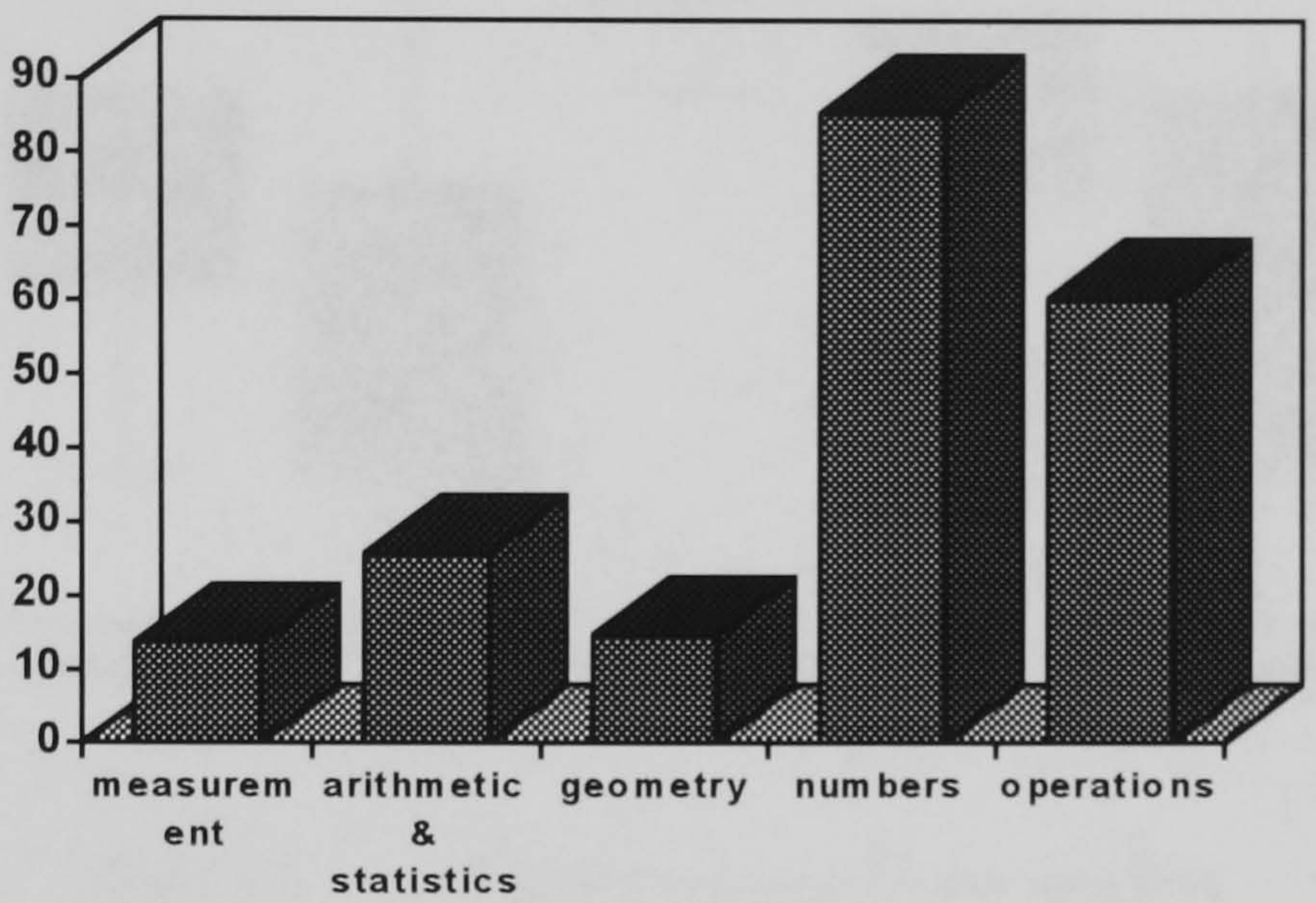
and 12.6 per cent of the teachers, respectively. In terms of what they actually enjoyed teaching, 50 per cent of the teachers indicated topics in basic number concepts. It is obvious from the graph that only a minority (about 7 per cent) of the teachers enjoy teaching topics in geometry and measurement. Totals of the teachers' response options for the five topic areas, which indicated the extents to which topics in these areas were actually taught by the teachers in the 1991/92 school year, were also determined. Table 6.3. shows summaries of the total responses made on the five topic areas.

Table 6. 3 Teachers' coverage of topic categories in instruction in the 1991/92 school year

Category of topics	Number of teachers not covering topic	Number of teachers covering topic	Number of teachers highly covering or emphasising topic
Basic number and fractional concepts	0 (0%)	20 (14.6%)	117 (85.4%)
Commercial arithmetic and data handling	27 (30.3%)	39 (43.8%)	23 (25.8%)
Geometric concepts	26 (22.4%)	73 (62.9%)	17 (14.7%)
Measurement concepts	30 (22.9%)	83 (63.4%)	18 (13.7%)
Number operations	0 (0%)	50 (39.6%)	76 (60.4%)

The second column in Table 6.3 shows that topics in commercial arithmetic and data handling, geometric concepts, and measurement concepts were not taught at all by over 20 per cent of the teachers. That is, as many as 30, 22 and 23 per cent of the teachers indicated they do not at all teach topics in commercial arithmetic and data handling, geometric concepts, and measurement concepts respectively. The fourth column in Table 6.3 shows the proportion of teachers emphasising topics in each category. The results in this column are presented in the graph in Figure 6.4.

Figure 6. 4 Proportion of teachers emphasising content in the five topic categories



The graph shows clearly that basic number concepts and number operations topic categories which include new maths topics like sets, algebra and points in the number plane, integers, and rational numbers, were emphasised by 70% or more of the teachers. It also shows that the other three categories were emphasised by only a small proportion (less than a quarter of the teachers in the sample).

The teachers' mean content coverage ratings, which are indicators of the extent to which they emphasised the twenty-five topics in their actual classroom teaching, are presented in Appendix 6.3. The ratings revealed that topics which teachers indicated as having given a good deal of teaching or rated high in their teaching are, once again, those that belong to basic number concepts and number operations. When applied to the other areas of content, the mean content coverage ratings indicate that the coverage of these areas is just modest. Figure 6.5 is a boxplot of the teachers' mean ratings of coverage of the topic categories.

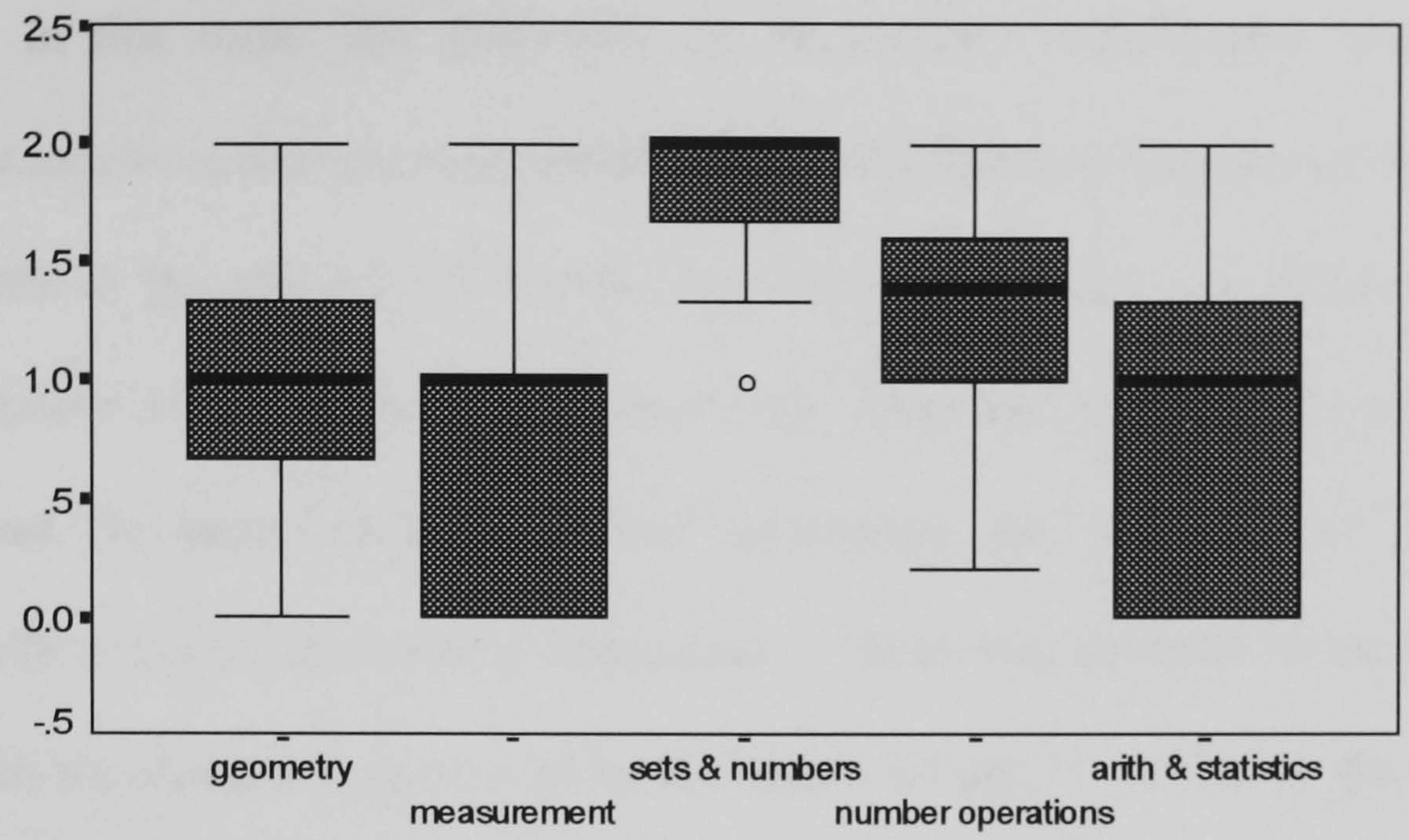


Figure 6. 5 *Teachers' coverage of topic categories*

In addition to showing that the coverage of topics in basic number concepts and number operations is very high, the figure shows that the variation within topic categories of teachers' coverage is not very uniform. The least within topic variability in teachers' coverage was observed in basic number concepts and number operations which had standard deviations of 0.28 and 0.48 respectively, and the others had standard deviations of about 0.6. It can therefore be argued teachers agree in their emphasis on topics in their instruction (including, sets and numbers, numbers and numerals, whole numbers & operations, fractions, and fractions & operations).

6.2.3 The adaptation of the subject matter content of the curriculum at the classroom level

In this study, the adaptation of *the primary mathematics curriculum* at classroom level was conceptualised in terms of differences between coverage of the content at the educational system, and classroom, levels. In other words, the adaptation was observed in respect of the difference between 'coverage of the content recommended in the official curriculum' and 'coverage of the content actually presented in teachers' instruction'. These two elements of the curriculum will be represented from now on by the letters '***O***' and '***I***'. (That is, the first letter, *O*, stands for 'coverage of the **O**fficial curriculum'; and the second, *I*, stands for 'coverage in teachers' **I**nstruction'). The ratings for *O* were obtained by rating the estimates of coverage presented in Table 6.1 using the criteria described in Box 5.7 (see Section 5.4.2). The teachers' mean coverage scores (Appendix 6.3) were also rated to obtain the ratings for *I*. The ratings for the two forms of coverage (that is, for *O* and *I*) are presented in Appendix 6.4(a).

The criterion for rating coverage in the official curriculum (*O*), as explained in Section 5.4.2, was based on measures similar to that used by Porter *et al* (1988). But the criterion for coverage in teachers instruction was based on both student-teachers' ratings and the researcher's expert judgment on the amount of attention required by topics presented in the curriculum. In the ratings, the expression '*covered*' was used to describe the amount of coverage that would be ideal[2] for

[2] The amount of coverage was based mainly on the the researcher's expert judgment.

giving all learning outcomes that belong to a particular topic adequate attention. *Mentioned* was used where the amount of coverage was not up to what will be described as enough to give learning outcomes of a topic the required attention. Where the amount of coverage was far above what would be required to give learning outcomes of a topic adequate attention, the coverage was described as *emphasised.* It will be recollected from Chapter 5 that the task of identifying the kernels in context and classifying exercises under the three stages of mathematical activity -concepts, skills and applications - difficult and the frequencies obtained were subjective. For this reason, the ratings of *O* which were based on counts of kernels, and textbook exercises, were not used in the analysis.

The ratings of the estimates of *O* were compared to the ratings of *I* to examine if the emphasis in topics in the textbooks influence the emphasis in teachers' instruction. It can be seen from the results (see Appendix 6.4(a)) that when compared to the relative amount of attention given to the topics in the official curriculum, the attention given to all, except two, of the topics in teachers' instruction were either the same or higher. But as these two were topics which were classified as 'covered', it could be argued that the relative amount of coverage given to topics in teachers' instruction is either higher or the same as the relative amount of attention given to the topics in the official curriculum.

Table 6. 4 Relationship between emphasis in topics presented in teachers' instruction and in the official curriculum

(a) Emphasis in teachers' instruction by emphasis in the official curriculum (by syllabus objectives)

Ratings for coverage in teachers' instruction	Ratings for coverage in the official curriculum (by number of syllabus objectives) Mentioned (1)	Covered (2)	Emphasised (3)	Row Total
Mentioned (1)	8[3] [a] *32*[b]	1 *4*	0 *0*	9
Covered (2)	8 *32*	2 *8*	1 *4*	11
Emphasised (3)	1 *4*	1 *4*	3 *12*	5
Column Total	17 *68.0*	4 *16.0*	4 *16.0*	25 *100*

(b) Emphasis in teachers' instruction by emphasis in the official curriculum (by textbook pages)

Ratings for coverage in teachers' instruction	Ratings for coverage in the official curriculum (by number of textbook pages) Mentioned (1)	Covered (2)	Emphasised (3)	Row Total
Mentioned (1)	1 *6.3*			1 *6.3*
Covered (2)	5 *31.3*	4 *25.0*	2 *12.5*	11 *68.8*
Emphasised (3)		2 *12.5*	2 *12.5*	4 *25.0*
Column Total	6 37.5	6 37.5	4 25.0	16 100.0

The cross tabulations of the emphasis on topics in textbooks and in teachers' instruction, presented in Tables 6.4(a) and (b), show a direct relationship between *O* and *I*. Topics that were mentioned in textbooks were most likely to be

[3] The top entry in each box represents the count of topics rated; the bottom entry in each box represents the percentage of the number of topics counted expressed as a percentage of the total number of topics considered.

mentioned or covered in teachers' instruction. Also topics covered in the textbooks were most likely to be covered or emphasised in instruction. Similarly, for those ratings of *O* based on counts of syllabus objectives, topics emphasised in textbooks were most likely to be emphasised in instruction.

The mean square contingency coefficient obtained for the results in the two tables (i.e. *O* based on textbook pages and syllabus objectives) were 0.498 and 0.478 respectively. The observed significant levels of 0.014 and 0.035 associated with the two values suggest the two variables cannot be independent. That is, the chance that a pair of ratings selected from the variables will not satisfy this relation is less than one in 20. In other words, the coverage of textbooks do influence the emphasis on topics presented in teachers' instruction. These results are not very different from the findings of Freeman and Porter (1989) who recorded a mean square contingency coefficient of 0.39 for the relationship between the content presented in textbooks and the content actually taught in elementary school mathematics. This implies that there is a substantial agreement between the emphasis in the content of instruction, and the content of the official curriculum, and therefore the extent to which teachers are able to adapt the official curriculum at the classroom level can certainly not be low as claimed by the educational authorities.

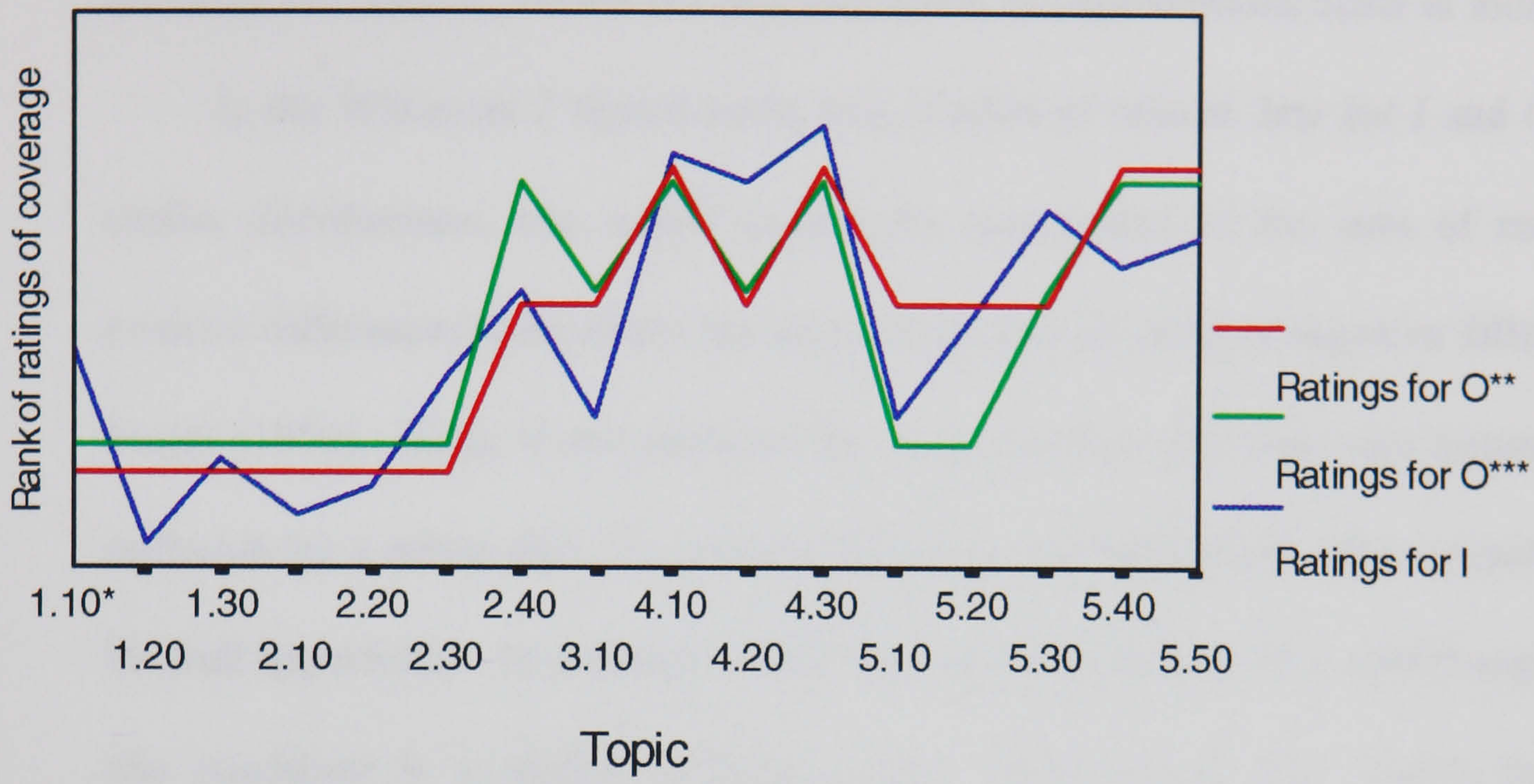
The extent to which teachers adapt the curriculum at the classroom level was judged, in terms of the definition proposed by Smylie (1994) as the difference in emphasis in content presented in teachers' instruction and content presented in the official curriculum. One way to measure such a difference statistically is to examine the distributions obtained for the ratings of the estimates of *O* and *I*. For the adaptation of the curriculum to be regarded as satisfactory, or not different from what was expected, a statistical test would be required to establish that the ratings of *O* and *I*, have equivalent distributions. In simple terms, the test must establish whether the rank order of ratings of *O* and *I* are identical or not. If the distributions are identical, then topics rated as having the highest amount of coverage in teachers' instruction are very likely to be those with the highest amount of coverage in the official curriculum.

A quick glance at the ratings of *O* and *I*, presented in Figure 6.6[4], reveals that the differences in the emphases on content (expressed by the related pairs of ratings of *O* and *I*) are small. To verify whether the differences between the related pairs of ratings are statistically small, the data was subjected to further analysis. The Wilcoxon *T* signed-ranks test was used to verify the claim of no difference in emphasis in the content of teachers' instruction and that presented in the official curriculum. The Wilcoxon *T* signed-ranks test was selected to investigate if the two distributions are equivalent because the data being compared is an ordinal level data, and also because the data comprise matched-pairs implying it had come from a related design. According to Coolican (1990, p187), the conditions which must be met before using this test are that the distributions should consist of "data of at

[4] See Appendix 6.4 for the Table of the ratings.

least ordinal level, and data from a related design". Since the test is described in detail elsewhere[5] only a brief summary will be provided here.

Figure 6. 6 *Ratings of* O *and* I



*These numbers are the codes associated with the topics considered.
**Ratings by textbook pages; ***Ratings by syllabus objectives.

The Wilcoxon T signed-ranks test makes use of paired observations of the form (I_i, O_i) and their differences (D_i). The latter, D_i, is the difference score for any matched pair which represents the difference between the pair's scores under the two distributions, that is, $I_i - O_i$. Each pair has one D_i. To use the test, all the D_i's are ranked without regard to sign. The rank of 1 is given to the smallest D_i, the rank of 2 to the next smallest, etc. When one ranks scores without respect to sign, a D_i of -1 is given a lower rank than a D_i of either -2 or $+2$. Thus the test uses information about the direction of differences within pairs of related data. The test

[5] Detailed discussion on the rationale and method for the Wilcoxon Signed-Ranks test can be obtained from Siegel (1956), Coolican (1990), Mendenhall, Wackerly, and Scheaffer (1990).

is used to examine pairs of related data to see if the sum of ranks of positive differences are equal to, or greater than, the sum of ranks of negative differences. It is used when one is interested in testing the hypothesis that two sets of data have the same distribution, versus the alternative that the distributions differ in location.

In the Wilcoxon *T* signed-ranks test, if pairs of related data for *I* and *O* have similar distributions, one would expect the magnitudes of the sum of ranks of positive differences to be about the same as the sum of ranks of negative differences Siegel (1956). Thus, if one summed the ranks having a plus sign and summed the ranks having a minus sign, one should expect the two sums to be about equal under the null hypothesis. Mendenhall, Wackerly, and Scheaffer (1990, p680) expressed this condition in a slightly different way. They stated that "under the null hypothesis of no difference in the distributions of the *I*'s and *O*'s, one would expect (on average) half of the differences in the pairs to be negative and half to be positive". In this sense, sizeable differences in the sums of the ranks assigned to the positive and negative differences would provide evidence to indicate a shift in location between the distributions. That is, if the sum of the positive ranks is very much different from the sum of the negative ranks, one would infer that distribution *I* differs from distribution *O*.

To carry out the Wilcoxon *T* signed-ranks test, first, a hypothesis was formulated on the question to be examined. The null hypothesis (H_o) for the test was that "the distribution of the emphasis in topics in teachers' instruction (*I*), and the distribution of the emphasis in topics in the official curriculum (*O*) do not differ", (that is, $H_o \rightarrow I = O$). The alternative hypothesis H_1 was that "the distributions I and O differ", (that is, $H_1 \rightarrow I \neq O$). Secondly, the Wilcoxon 'T' statistic was calculated. As procedures involved in calculating this statistic have been described in details in several sources (Siegel, 1956; Coolican, 1990; and Mendenhall, Wackerly, & Scheaffer, 1990), it will not be discussed any further here.

The T statistics (based on the differences between the ranks of the estimates of I and O) obtained were used to test[6] the null hypothesis stated above. The z-scores for the Wilcoxon 'T' statistic for the test for differences between the distributions of the extent to which content in topics are emphasised in the official curriculum and in teachers' instruction were calculated with the aid of the SPSS computer software and the results are presented in Table 6.5 (see Table 6.5b in Appendix 6.4 for details).

Table 6. 5 Difference between of ratings of teachers' content coverage (I) and coverage of content in the official curriculum (O)

	Wilcoxon 'T' statistic	Z-scores for Wilcoxon 'T' statistic	Probability
I based teachers' self-rating of coverage. O based on counts of textbook pages	10	-1.4809	0.1386
I based teachers' self-rating of coverage. O based on counts of syllabus	16.5	-1.4670	0.1424

With both estimates of coverage of content recommended in the official curriculum, the results of the test presented in the table yielded probabilities higher than the predetermined level of $p \leq 0.05$. That is, no significant differences were found

[6] See Appendix 6.4 for a description of the test.

between the distribution of the emphasis in topics in teachers' instruction (*I*), and the distribution of the emphasis in topics in the official curriculum (*O*). The null hypothesis that 'the distribution of the emphasis in topics in teachers' instruction (*I*), and the distribution of the emphasis in topics in the official curriculum (*O*) do not differ' could therefore not be rejected. It can therefore be concluded that in terms of relative amount of attention given to topics, there is no difference in emphasis in the content of teachers' instruction and that presented in the official curriculum.

6.3 The adaptation of teaching methods at the classroom level

The data on adaptation of teaching methods at the classroom level was presented in three parts. First, the teaching method underpinning the learning and teaching activities in the official curriculum was examined. Then the data on the teaching method emphasised in teachers' mathematics instruction were presented. These included ratings on how often selected teaching skills were used in teachers' instruction. The adaptation of the method recommended in the official curriculum, which involved a comparison of the data presented on the teaching method underpinning the official curriculum and teachers' actual instruction, was considered finally.

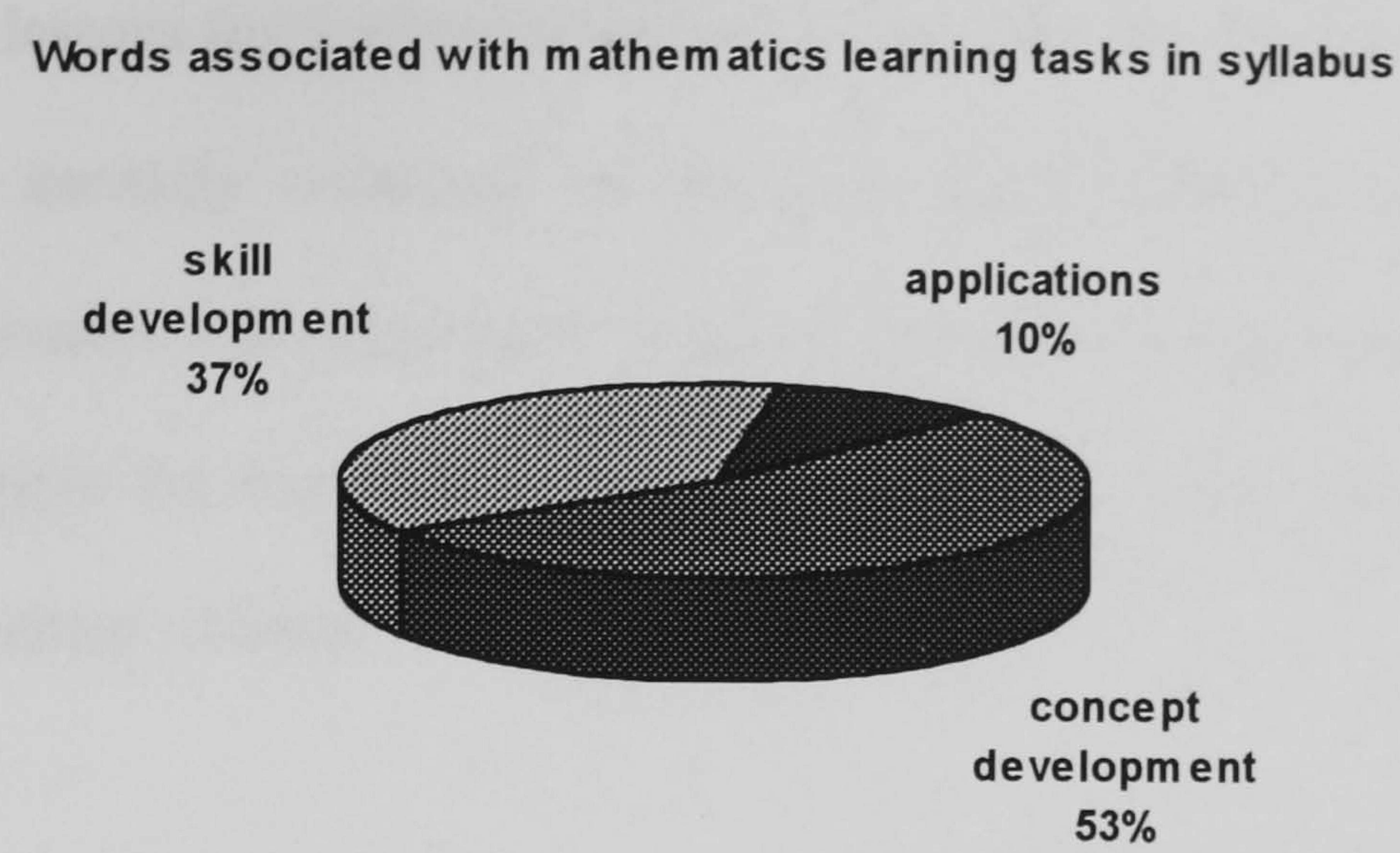
6.3.1 Teaching method emphasised in the official curriculum

In Table 5.5 in the previous chapter, it was indicated that three forms of data were together used in determining if the official curriculum emphasised the use of the discovery teaching method. The first was counts of words in the official syllabus related to processes associated with the three stages of mathematical activity- concepts development, skills development, and application of concepts. The second was the number of instructions on teaching activities in the teacher's handbooks suggesting the three common forms of classroom organisation - whole class, individual, and small group. The third was number of instructions on the teaching activities in the teacher's handbooks suggesting the four common classroom-exchange types - elicit, inform, direct and checking. In this section, the teaching method emphasised by the official curriculum will be discussed in the light of these units of analysis.

6.3.1.1 Mathematical processes and type of classroom organisation emphasised

Counts of words in the syllabus describing mental processes associated with the three stages of mathematical activity were considered to see the stage(s) of mathematical activity, in respect of those outlined in Brissenden's framework, emphasised by the official curriculum. The proportions of words found with respect to the three stages- concept development, skill development and applications- are presented in Figure 6.7.

Figure 6. 7 Counts of words associated with mathematics learning tasks presented in the official syllabus



The figure indicates that the mental processes which allow for the development of concepts are the most emphasised. This is followed by processes which allow for the development of skills in computations. It shows that 53% of the words counted as related to the development of concepts which shows that the syllabus emphasises the development of concepts through such processes as counting, classifying, estimating, matching, ordering, re-naming, comparing, describing, and identifying, to mention only a few. Although this is an important attribute of the discovery teaching method this does not necessarily imply the syllabus emphasises this method, therefore the actual teaching and learning activities presented in the teacher's handbooks were systematically examined to see if the concepts have been presented in such a way as to be encountered through discovery.

The instructions[7] in the teacher's handbook, provide detailed guidance on specific actions to be undertaken by the teacher. They also include tasks to be

[7] The nature of the instructions can be seen in the descriptions of some of the teaching activities taken from Unit 2 of the Primary 3 Teacher's Handbook reproduced in Box 5. 5. in Chapter 5.

given to pupils and responses to expect from pupils. The instructions suggested on eight lessons (or teaching activities) taken from the Primary 3 teacher's handbook were carefully examined to see how often different patterns of classroom organisation were employed. Figure 6.8 shows the proportions of instructions[8] found to suggest the organisation of classroom teaching under whole-class, individual and small-group activities.

Figure 6. 8 Proportion of instructions in teacher's handbook suggesting classroom organisation under - individual, small-groups, and whole-class

As many as 86% of the instructions (or statements) in the activities examined in the teacher's handbooks require the teacher to operate in whole-class teaching, while only 11% and 3% suggest activities with individuals or small-groups respectively. None of the instructions included teacher-actions like *instigate, listen* and *observe* which are useful in directing exploratory activities highly recommended in the introductory part of the syllabus. It can be argued that the official curriculum

[8] Appendix 6.5 shows the detailed frequency distribtion of key or cue words in the instructions considered for the different forms of classroom organization - whole-class, individual and small-group. The words were considered in the statements in which they occur and classified accordingly.

intends mathematical lessons to be organised mainly in whole-class teaching sessions. Even though concept development is emphasised, this result suggests the concepts are to be learned mainly through whole-class teaching where learners learn concepts by reception rather than discovery. Furthermore, it was found that the instructions were highly structured towards specific outcomes with no suggestions offered for alternate options, or for methods leading to similar outcomes. It was also found that no suggestions for creative work and investigative work were included. The lack of emphasis on applications and the silence over individual and group work which promote cooperative learning, pupil-directed and small-group learning, indicate that the official curriculum designers did not provide guidance on how and when the discovery method should be used.

6.3.1.2 Discourse patterns, and nature of pupils' responses, underpinning activities in the official curriculum

The statements in the instructions were also examined for the types of classroom exchanges- eliciting, informing, directing or checking- they involve. The discourse patterns involved in these exchanges were described in terms of permutation of three basic forms of exchanges- Initiation (I), Response (R), and Feedback (F). For instance, elicit exchanges are of the form IR(F), that is, initiation and response, but occasionally with feedback. Details of the permutations of the other three types of exchanges will be found in Section 5.4.3.2.

The analysis of the transcribed lesson activities (see Box 5.6 for an extract), indicated that instructions in the teacher's handbooks follow a common pattern of classroom discourse. In this common pattern, the teacher initiates a move (usually eliciting a verbal response) for a response from individual pupils or pupils in chorus. These are occasionally followed by feedback. In terms of the types of classroom exchanges they are intended for, the instructions in the teacher's handbooks may be described mainly as *elicit* and *inform* exchanges. These are exchanges in which teacher initiation moves predominate. The greater part of the instructions elicit responses that are highly structured towards specific responses from pupils. These responses are often in the form of short phrases used in expressing agreement with the teacher or a single word used in expressing the answer to a question. Hardly ever do these responses entail full sentences. The other forms of exchanges- *direct* and *checking*- were left to the teacher's discretion.

The instructions in the teacher's handbooks generally follow the pattern of lesson presentation used by Mrs Addo, described in Section 4.4.4. This pattern can be described as 'teacher-led class discussion using situations and examples, followed by pupils' examples and exercises. That is, the instructions involve activities that are mainly combinations of A1 $\rightarrow$ B1 $\rightarrow$ B2 type activities in the framework suggested by Brissenden (1980). The teaching and learning activities in the official curriculum can therefore be said to subscribe to the expository or traditional teaching method

6.3.2 Teaching method emphasised in teachers' mathematics instruction

In this study, teachers' use of the discovery teaching method in their classroom practice was examined in terms of-'how often teaching skills that increase the chances of the pupils' discovery'- were used in instruction. As explained in Section 5.4.3, the frequencies of teachers' use of these teaching skills were obtained by two supplementary processes. One was through observation by trained assistants and rating of frequencies of using the skills, and the other was by analysis of tape-recorded lesson transcripts. In the lesson transcripts analysis, the emphasis on the discovery method, was considered in terms of the types of exchanges, and nature of pupils' responses, involved in discourse patterns observed in teachers' lessons. Teaching skills the researcher considered as important in increasing the chances of the pupils' discovery, were tested by questionnaire (see Appendix 5.4), and the results were summarised by a factor analysis in Section 5.4.3. Composite scores of the categories of teaching skills obtained in the factor analysis provided data on how often teachers used the skills.

6.3.2.1 Teaching skills emphasised

The skills identified in the factor analysis as '*motivational, small group & individual instruction, and thinking development*' skills, are presented in Table 6.6. The table shows the proportion of teachers found never using these skills, and the proportion found using these skills occasionally or often. From the table, it will be realised that except for the display of confidence in teaching, and the putting of effort into pre-lesson preparation, all the skills identified here were used only occasionally.

Table 6. 6 Teachers' use of 'motivational, small group & individual instruction, and thinking development' skills

Teaching skills	Percentage of teachers		
	Never	Occasionally	Often
Sending meaningful reports to parents	53.5	44.2	2.3
Using approaches that bring conceptual understanding and not mere knowledge of techniques	18.2	63.6	18.2
Encouraging the use of pupils' own methods in solving problems	95.5	4.5	0
Criticising, constructively, pupils' work	0	51.2	48.8
Making valuable comments after marking pupils work	81.8	18.2	0
Ensuring all pupils are involved in lesson	20.9	76.7	2.3
Identifying and helping pupils in need of special attention	2.3	76.7	20.9
Basing preparation of weekly lesson notes on pupils' previous performance	25.0	65.9	9.1
Teaching with confidence topics presented in lessons	2.4	23.8	73.8
Putting a good deal of effort into pre-lesson preparation	0	19.5	80.5

Since skills used in (a) motivating pupils to learn, (b) organising small group and individual instruction, and (c) developing pupils' thinking, are enhanced by the creation of variety of learning situations using different teaching and learning resources, which involve the management of the limited learning/teaching resources available to meet the divergent needs of pupils, composite scores of the fourth group of teaching skills obtained were also examined. Table 6.7 presents the skills required in evaluating and managing teaching/learning resources, the proportion of teachers found never using these skills, and the proportion found using these skills occasionally or often.

Table 6. 7 Teachers' use of evaluative and teaching/learning resources management' skills

Teaching skills	Percentage of teachers		
	Never	Occasionally	Often
Giving meaningful answers to pupils' questions	82.9	2.4	14.6
Preparing and using teaching/learning material in lessons	45.5	54.5	0
Setting and marking of homework	58.1	34.9	7.0
Engaging pupils in practical and game activities in lessons	68.2	31.8	0

The infrequent use of teaching and learning materials, practical and game activities. can be seen in the table. The table shows 45.5 per cent of the teachers were found to be teaching without teaching/learning materials; 68.2 per cent of them presented lessons without engaging the pupils in practical tasks and none of them used games in their lesson presentations. Materials which are conveniently within the reach of the teachers in and around the classroom or "opportunity aids" were the only teaching learning resources used by the few who were occasionally found to use resources. Examples of such opportunity aids are the pupils themselves, windows, doors, tables, chairs, objects on and around the compound like trees, paths, lawns, houses, animals and passing vehicles. As a consequence of the infrequent use of teaching/learning materials and practical activities, pupils have little chance of asking questions. Just about 17 per cent of the teachers were found to have provided meaningful answers to pupils' questions mainly because many of the teachers hardly engaged pupils in activities which will urge them to ask questions.

The success in fostering inquiry and guiding discovery in the classroom depends on the teacher's communication and presentation skills. The proportion of teachers found never using these skills, and the proportion found using these skills occasionally or often, are presented in Table 6.8. Though about 70 per cent of the teachers were found to be teaching challenging mathematics , as many as 98 per cent of them were found using solely examples and exercises set in the official textbooks. The table also shows that the majority of teachers make pupils to use only the standard textbook methods irrespective of their abilities.

Table 6. 8 Teachers' use of presentation and communication skills

Teaching skills	Percentage of teachers		
	Never	Occasionally	Often
Using mainly textbook examples and exercises	2.3	0	97.7
Using methods which do not encourage discussions	11.6	9.3	79.1
Explaining mathematics so that pupil's can understand	0	7.0	93.0
Showing enthusiasm in mathematics teaching	9.3	58.1	32.6
Using humour to make mathematics lessons interesting	51.2	41.9	7.0
Teaching challenging mathematics from only textbooks	0	29.5	70.5
Using mainly formal assessment techniques	0	4.7	95.3
Geting into difficulty while teaching mathematics	4.7	76.7	18.6
Making pupils afraid when teaching mathematics	41.9	53.5	4.7

A little above 30 per cent of the teachers were found to occasionally present methods other than the standard textbook methods suggested in the textbook. Besides the observation that most of the teachers (about 70 per cent) did not encourage discussions in the classroom during lessons, it was found that more than 90 per cent of the teachers were able to explain mathematics for pupils to understand. The lack of discussion implies teachers' style of lesson presentation involved mainly their exposition rather than pupils' activity.

The frequencies of using the skills were rated from a minimum of "1" for 'never used', to a maximum of "3" for 'often used', to increase pupils' chances of learning by discovery. The composite scores for presentation and communication skills, as will be seen in Table 6.9, are not very different from the ratings obtained for the teachers' use of motivational , small group and individual instruction, and thinking development, skills, which yielded minimum and maximum ratings of 1.25 and 2.40 respectively, and a mean rating of 1.97.

Table 6. 9 Mean ratings of teachers' frequency of using the categories of teaching skills

Category of teaching skills	Mean	Standard Deviation	Minimum	Maximum
Motivational, small group & individual instruction, and thinking development skills	1.97	.23	1.25	2.40
Communication skills	1.80	.29	1.00	2.60
Presentation skills	2.02	.24	1.50	3.00
Evaluative and teaching/learning resources management skills	1.41	.35	1.00	2.25

Comparing the standard deviations obtained here to what was obtained for teachers' coverage of content (see Appendix 6.3), it will be realised that the standard deviations obtained are low. The comparatively low standard deviations obtained here suggest there are not very much differences from one teacher to another on how frequently they employed the skills in the categories. The composite scores for evaluative, and teaching/learning resources management, skills was however different. It had a low mean of 1.41, and also the lowest value in the '*maximum*' ratings column in the table. This suggests the ratings on evaluative, and teaching/learning resources management skills were nearer '*never used*' than '*occasionally used*'. The implication is this category of skills, which are very necessary if pupils are to discover the mathematics they learn, are infrequently used. Since the teachers demonstrated less use of such skills, it can be argued that teachers do not intend pupils to encounter what they teach through discovery learning.

The composite mean ratings of teachers' frequency of using the teaching skills, were compared with the teachers' mean content coverage ratings (Section 5.4.2). Differences in frequencies of using the groups of skills by teachers who mentioned, covered or emphasised, content in their instruction were statistically analysed. The results of the test of differences among teachers who mentioned, covered or emphasised, content (in the five topic categories) in their use of the skills, can be seen in Appendix 6.6. Since the test revealed no significant differences between the teachers who mentioned, covered, or emphasised, the content actually presented in their instruction, the results will not be discussed.

A cursory inspection of pupils' exercise books during the researcher's visits to schools revealed that exercises set by teachers involve mainly those that give practice in number computations. In other words, routine tasks involving mainly skill exercises were the learning tasks most frequently presented in teachers' instruction. The failure of the teachers to use structured teaching materials and practical and game activities, and to rely solely on textbook routine tasks, indicate that the few who attempt to teach for conceptual understanding and application rely mainly on exposition and teach for reception and not discovery learning. Whether the teachers' expository styles are 'structured' or 'amorphous' depends on the nature of their classroom organisation and pattern of classroom discourse which are considered in the next section.

6.3.2.2 Actual classroom discourse patterns, and nature of pupils' responses

The units of analysis employed in analysing the transcripts of the three tape-recorded lessons have been described in detail in Section 5.4.3.2. These include the different classroom exchanges, and the pupils' responses judged according to whether they belonged to echo, routine, and real, responses, and also whether they were given by an individual pupil, pupils speaking simultaneously or pupils speaking in chorus. As the discourse patterns employed in describing the classroom exchanges were used above in considering the exchanges involved in the activities presented in the teacher's handbooks (Section 6.3.2.1), it will not be discussed further here. Table 6.10 shows the proportion of classroom exchanges recorded in the three tape-recorded lessons under the four types of classroom exchanges - eliciting, informing, directing and checking.

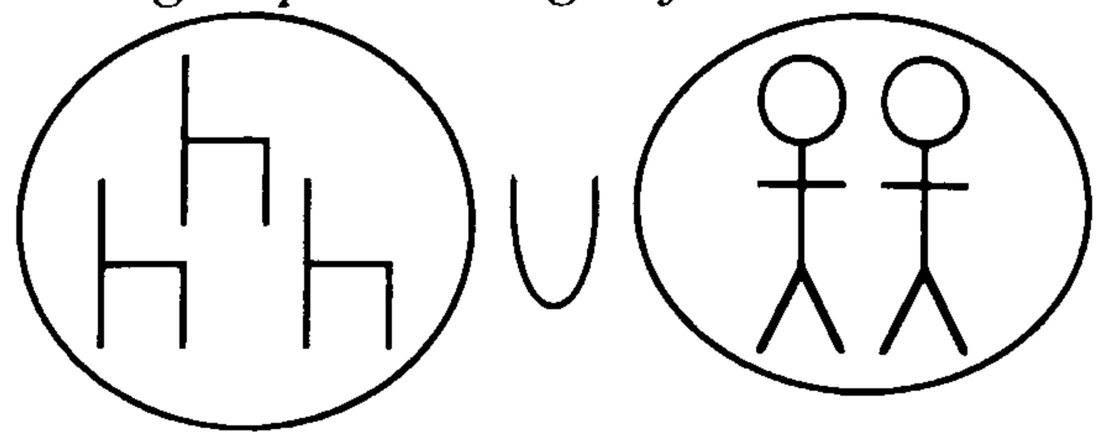
Table 6. 10 Classroom exchanges from transcripts of three tape-recorded lesson extracts

	Number of exchanges judged			
	Elicit [IR(F)]	**Inform** [I]	**Direct** [IR]	**Checking** [F]
Lesson 1 (Age 12)				
count	24	3	7	2
	(67%)	(8%)	(19%)	(5%)
Lesson 2 (Age 6)				
count	10	1	3	0
	(71%)	(7%)	(21%)	(0%)
Lesson 3 (Age 9)				
count	25	3	2	1
	(80%)	(10%)	(6%)	(3%)

Teacher-led elicit exchanges with responses either from an individual or a large number of pupils in a class was the most common form of classroom exchange observed. In all three lessons this, together with teacher-led inform exchanges, constituted more than 70% of the exchanges. That is, the teachers used mainly exchanges that elicit verbal information regarding mathematical principles being learned; as in the following extract [L2: 4-6][9] :

[9] References in square brackets refer to specific classroom exchanges taken from the transripts of lesson extracts included in Appendix 5.6. For example, [L2: 4 - 6] refers to Lesson2, exchange numbers 4, 5 and 6.

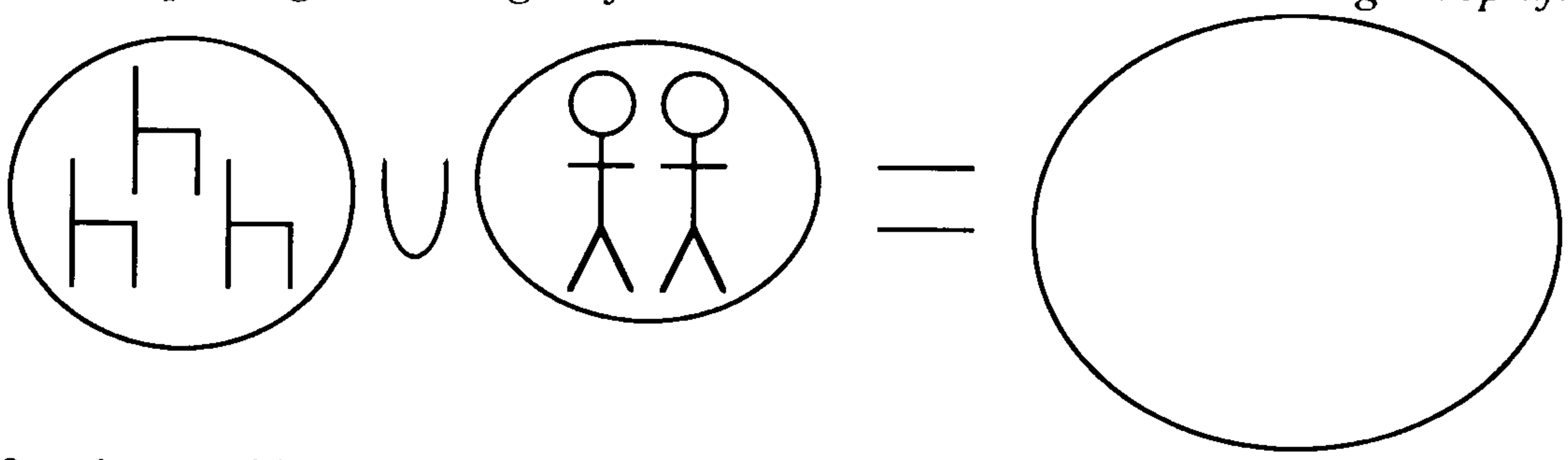
(Teacher asked two groups standing in front to take their seats.



She draws two sets with a 'U' sign between them on board).

T[10]	How many members are in this set?
	(pointing to the set on the left) .... Yes Botse?
Pb :	three
T :	Good
T :	How many members are in the other set? ...
Pj :	two
T :	Fine. You .... eh, Joyce.

(Teacher wrote an equal sign to the right of the sets on the board and drew a large loop after it).



T	If we have a third set, (*pointing to the loop*), a big set, and bringing together the two small sets, how many members shall we have in the big set?..
C :	////////// [*responses which were not clearly audible from the tape*].

The other forms of exchanges- directing and checking exchanges,- whose use can make pupils more likely to encounter the learning of the mathematical principles by discovering by themselves, constituted just under a quarter of the exchanges recorded in each lesson.

Pupils' verbal responses observed were classified using the three categories used by Messenger (1990) - echo, routine and real responses and also by considering whether they were given by pupils speaking in chorus, pupils speaking

[10] Full details of conventions used can be found in Appendix 5.8. In the above extract, -

Px (where x is a letter) → a pupil with the initial xy who was called by name by the teacher

T→ teacher

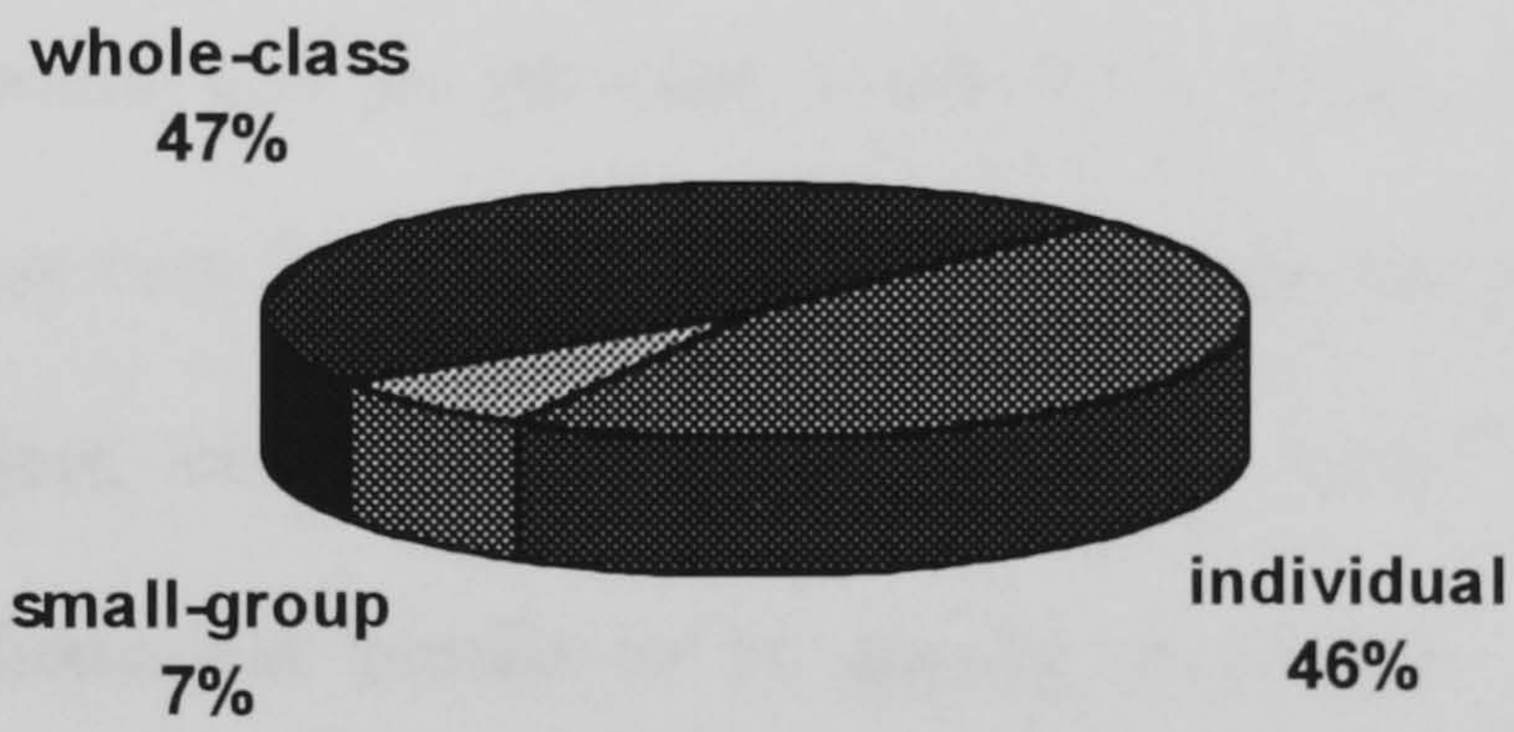
C→ class (or a large number of pupils) making a response simultaneously or by an individual pupil. Even though the classification of responses in the tape-recorded lessons into the three categories required some amount of subjectivity, the analysis presented in Table 6.11 provide some indication of the nature of 'pupil participation' in the lessons.

Table 6. 11 Analysis of pupils responses in classroom exchanges

Nature of Response	Choral	Simultaneous	Individual	Total
Echo				
Lesson 1 (p.6)	5	0	0	5 (11%)
Lesson 2 (p.1)	0	0	0	0 (0%)
Lesson 3 (p.3)	11	0	0	11 (38%)
Routine				
Lesson 1 (p.6)	4	0	0	4 (8%)
Lesson 2 (p.1)	2	0	0	2 (12%)
Lesson 3 (p.3)	3	2	0	5 (17%)
Real				
Lesson 1 (p.6)	14	2	23	39 (82%)
Lesson 2 (p.1)	1	2	12	15 (88%)
Lesson 3 (p.3)	4	1	8	13 (45%)
Total				
Lesson 1 (p.6)	23 (48%)	2(4%)	23 (48%)	48 (100%)
Lesson 2 (p.1)	3 (18%)	2(12%)	12 (70%)	17 (100%)
Lesson 3 (p.3)	18 (62%)	3(10%)	8 (28%)	29 (100%)

Even though substantial proportions of the pupils' responses (that is, 82%, 88% and 45% of the responses in Lessons 1, 2 and 3 respectively) were real (that is based on thought and decision), they were mainly made by the same few individual pupils who were the focus of most of the teacher's contact with the class. Usually, these individuals constituted a minority of the class and they were the few more able pupils who were able to follow the teacher's instruction and who also dictated the pace of the teacher's presentation. For most of the pupils however, the only form of participation in the classroom discourse was through choral responses. These responses, though they were real, were mainly those that require less thought, like recognition of terms, symbols, notations and fractions or counts of sets of objects. Simultaneous responses occurred but usually in exchanges in which the teacher delayed in deciding who should answer a question or carry out his or her request. The exchange patterns and nature of pupils' responses indicate that teachers hardly ever engage pupils in small-group activities. Using frequencies of choral, individual and simultaneous responses as proxies for how often classroom teaching was organised under whole-class, individual and small-group sessions, the summaries of the analysis in Table 6.11 have been presented in a graph (Figure 6.9) to delineate how whole-class teaching is emphasised in the classroom organisation.

Figure 6. 9 Frequencies of pupils' responses delineating classroom organisation under - whole-class, individual and small-groups



One thing I have learned during my nine year long career as a teacher trainer in Ghana is that the extent of pupil participation in lessons are generally judged by pupils' individual encounters with the teacher during whole-class teaching sessions. The close match between the individual and whole-class teaching sessions delineated by the responses in the figure above supports the observation that 'individual instruction' is analogous to the learners' individual encounters with the teacher during whole-class teaching sessions.

The lesson approach in all classrooms followed a similar pattern.[11]. There was little or no contrast between the sequence of presentation, form of classroom organisation and classroom discourse from one teacher's class to another's. The sequence and content of presentation generally follow the pattern of lesson presentation used by Mr Kofie, described in Section 4.4.4. This pattern can be described as 'teacher-led class discussion using situations and examples, followed by pupils' examples and exercises. The teaching steps used by the teachers involve activities that are mainly combinations of A1 $\rightarrow$ B1 $\rightarrow$ B2 type activities in the framework suggested by Brissenden (1980). The researcher's earlier[12] experience of work in classrooms, and his personal observations during the course of this study, indicated that very little or no use is made in schools of approaches like theme, topic, project, cross-curricular and integrated work[13], which make it necessary for mathematical kernels to be applied in context. Where contexts related to real life were used, they formed only part of the introduction of the lesson, often about a fifth of the lesson time. Contexts related to simulation involve only shopping activities. Contexts related to games are completely non-existent.

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[11] See Appendix 5.8 for transcriptions of lessons which were taped from three different classrooms

[12] The researcher taught at the primary level in the Winneba District for three years (1975 to 1978), and worked as a teacher trainer in a primary teachers training college for seven years (1981 -1988).

[13] For details on the researcher's observations on the decline of cross curricular work in schools, refer to Mereku (1992b).

6.3.3 The level of adaptation of teaching methods at the classroom level

The introductory part of the official syllabus and the teacher's handbooks were systematically examined for the method intended to be used in presenting the content recommended in the official curriculum. Two quotations taken from the introductory part of the official syllabus indicate the curriculum developer's position on what constitutes a desirable mathematics teaching method by which pupils should encounter the learning of the content of the curriculum at this level. The first is

> ".... teachers (should) create learning situations and provide guided opportunities for children to acquire as much knowledge and understanding of mathematics as possible through their own activities" (CRDD, 1988, p5).

and the other is

> There are times when the teacher must show, demonstrate, tell and explain. But the major part of a child's learning experience should consist of opportunities to explore various mathematical situations in his environment to enable him to make his own observations and record them in pictures and/or words. The child would learn to compare, classify, analyse, look for patterns, spot relationships and come to his own conclusions.....
> ...In the development of concepts, children can be motivated and their interest aroused and maintained through the following stages: PLAY, STRUCTURED EXPERIENCE followed by PRACTICE (CRDD, 1988, p5).

The first quotation suggests that pupils should be made to encounter the learning of the content of the curriculum through their own activities, or by the discovery method. This view is supported in the second quotation by emphasising the key words- *play, structured experience,* and *practice*- used by Dienes (1960: p.39), whose writings suggest advocacy of the discovery method, in describing the stages in the learning of a concept.

It is worthwhile noting that even though the quotations include suggestions on teaching skills that are intended to induce acquisition of mathematical knowledge through discovery learning, little mention is made of the word 'discovery' or the expression 'discovery learning' in the whole of the introduction of the syllabus. The introduction to the teacher's handbooks however state that the books are intended "to help pupils to discover the ideas of mathematics so as to enjoy learning the subject" (CRDD 1986b). To ensure that pupils are helped to learn by discovery, the handbooks remind teachers that "a teacher teaches best when pupils are made to think for themselves", and recommend that he (the teacher) should "question and guide the pupils but say as little as possible, and he should listen to, and watch the pupils to know when they are ready to move to a new activity or stage".

To discover the idea

$$" \frac{a}{b} = \frac{a \times c}{b \times c} "$$

take pupils through the following activities:

a) revise with sheets and strips of paper different names for the same fraction equivalent fractions);
b) use a number or fractional line as a representation of the paper strip to find the equivalent fractions; and
c) guide pupils to look for a pattern or similarities in pairs of equivalent fractions like $\frac{1}{2} = \frac{3}{6}$; $\frac{1}{4} = \frac{2}{8}$; and $\frac{3}{4} = \frac{6}{8}$ to enable them to recognise their structure.
d) ask pupils to open their textbooks at bottom of page 110 and complete the sentences in their exercise books.

(Extracted from: Unit 10 of the Primary 3 teacher's handbook)

Figure 6. 10 An example of instructions on activities in the GMS Teacher's Handbook

But despite the rhetoric on the use of discovery method and the frequent use of the word- *discover*- in stating teaching objectives, instructions on teaching activities stated in the handbooks require the teacher mainly to demonstrate correct sequences of steps which lead to a conclusion, but not to engage pupils in the activities for them to arrive at the conclusion. An example of instructions on activities in the teacher's handbook, are those intended to be used to guide pupils to discover the relationship between two equivalent fractions, presented in Figure 6.10. In this activity, pupils are expected to realise a mathematical structure as their conclusion. The structure can be described as

> given any fraction, (for instance, $^a/_b$), another fraction equal to it can be obtained when the numerator and denominator are multiplied by the same number. And if c is the number used as the common multiplier, then the required structure can be symbolically expressed as

$$\frac{a}{b} = \frac{a}{b}\frac{x}{x}\frac{c}{c} = \frac{(a \ x \ c)}{(b \ x \ c)} = \frac{x}{y}.$$

The activities suggested in the instructions in the figure indicate this complex relationship is to be learned from teacher-led exposition and not by pupils' own discovery. Pupils' activity was mentioned only in the fourth instruction, and even in this case, it was an activity which involves pupils' individual practice, or what is termed by some teachers as seat work..

In the light of the sense in which the term discovery is used in the teacher's handbooks, it can be argued that the curriculum designers confuse its meaning with that of 'meaningful reception'. That is, the form of learning experienced by pupils when the teacher's exposition allows new learning materials taught to be both assimilated and interconnected with what already exists in pupils minds. The results of the analysis of the official syllabus and the teacher's handbooks strongly suggest that the learning and teaching activities recommended in the official curriculum favour the expository teaching method. The evidence therefore suggests that the designers of the curriculum did not really have a clear concept of how the curriculum might be presented by the discovery teaching method.

Adaptation of teaching method at classroom level is perceived in terms of differences between 'method emphasised in the official curriculum' and 'method actually employed in teachers' instruction'. In the light of what have been revealed as emphasised in both the official curriculum and teachers' actual instruction, the question of adaptation of teaching method is inappropriate. There can be no such question since the teaching and learning activities in the official curriculum subscribe to the expository or traditional teaching method which is the method which the teachers are familiar with and use in their instruction.

6. 4 Influence of personal characteristics and organisational factors on teachers' content coverage

The teachers' mean content coverage ratings, which are indicators of the extent to which they emphasised individual topics in their actual classroom teaching, were presented in Appendix 6.3. The composite mean content coverage ratings for the five areas of content, obtained by summarising the data in this table, are presented in Table 6.12.

Table 6. 12 Mean teachers' content coverage ratings for the five areas of content

Area of content	Mean	Standard Deviation	No. of teachers making responses
Geometric concepts	.93	.61	116
Commercial arithmetic and data	.94	.72	98
Measurement concepts	.91	.60	131
Number operations	1.63	.55	126
Basic number and fractional	1.78	.32	137

The differences in mean coverage of the areas of content is apparent from this table which shows basic number concepts and number operations as having mean content coverage ratings greater than 1.5 and the others having just under 1.00.

It will be recollected that one of the objects of the study is to investigate whether or not diversities in personal characteristics of teachers and organisational factors make any differences in the extent of their content coverage. In Section 6.4, the teachers' mean content coverage ratings are further analysed in respect of *personal characteristics* - teacher's sex, length of teaching experience, O'level mathematics qualification, participation in in-service education; and *organisational factors* - teacher's class, and teacher's class size.

The mean content coverage ratings obtained for the five areas of content presented in teachers' actual classroom teaching with respect to each of the personal and organisational characteristics can be seen in Table 6.13. It will be observed on inspection, from the table that under each of the characteristics, the teachers' mean content coverage ratings on each of the five areas of content differ slightly. Take for instance basic number concepts, it will be noticed that the mean content coverage ratings for male and female teachers are 1.85 and 1.73 respectively; and for teachers with qualification in O'level mathematics and those without the ratings are 1.79 and 1.76 respectively. To verify whether or not the differences in teachers with respect to the personal characteristics, and with respect to the organisational factors, have any effect on their content coverage required an appropriate statistical test.

Table 6. 13 Mean content coverage ratings by their personal characteristics and organisational factors

	Basic number concepts	Commercial arithmetic and data handling	Geometric concepts	Measurement concepts	Number operations
Teacher's sex					
female	1.85	.81	.90	.89	1.70
male	1.73	1.00	.95	.93	1.58
Length of teacher's teaching experience					
more than 3 years	1.81	.97	.94	.93	1.67
not more than 3 years	1.69	.89	.89	.87	1.52
Level of teacher's class					
lower primary	1.86	.82	.91	.79	1.90
upper primary	1.74	.97	.94	.97	1.51
Size of teacher's class					
not more than 35 pupils					1.68
more than 35 pupils	1.79	.86	.92	.98	1.59
	1.77	1.00	.94	.87	
Teacher's participation in in-service					
in-service courses ≤ 2	1.80	.90	.93	.92	1.64
in-service courses > 2	1.59	1.25	.93	.87	1.53
Teacher's qualification in O'level mathematics					
with no qualification	1.79	.94	.88	.84	1.67
with qualification	1.76	.96	.98	1.00	1.59

The data being examined were all in frequencies and could be presented in a cross tabulation. For instance, the cross tabulation of upper and lower primary teachers' coverage of content, can be seen in Table 6.14. The boxes in the table are called cells and the counts of observations or *observed frequencies* are the bold numbers. As the data was recorded as nominal level data and the variables - content coverage and the characteristics - are unrelated, the appropriate test that these conditions were found to meet was the chi-square test[14]. The test was used to answer questions such as the following:

1. Do teachers who teach in lower and upper primary classes give the same amount of emphasis to content area(s) in their instruction?
2. Do teachers with much of participation in in-service courses give more emphasis in their instruction to the content area(s) than teachers with little or no participation in in-service courses?

Table 6. 14 *Cross tabulation of content covered in teacher's instruction by level of teacher's class*

Level of teacher's class	Lower Primary	Upper Primary	Row Total
Not covered 1	**14*** 8.8 35.9%	**15** 20.2 16.9%	29 22.7%
Covered 2	**19** 24.7 48.7%	**62** 56.3 69.7%	81 63.3%
Emphasised 3	**6** 5.5 15.4%	**12** 12.5 13.5%	18 14.1%
Column Total	39 30.5%	89 69.5%	128 100.0%

[*In each column, the top figure represents the *Count* of teachers, the middle figure represents the expected value, and the bottom figure represents the Column percentage].

As how to carry out these steps have been described in details in several sources (Siegel, 1956; Coolican, 1990; Norusis 1991; Robson, 1993), it will not be discussed any further here. The chi-square (χ^2) values for the test for differences between teachers' mean content coverage ratings with respect to their personal

[14] For details about the assumptions required by non parametric tests of difference refer to Coolican (1991) and Robson (1993).

characteristics and organisational factors were calculated with the aid of the SPSS computer software and the results are presented in Table 15 - 29 respectively (see Appendix 6.6(b)).

With regard to coverage of topics in basic number concepts (Table 6.15), a significant difference ($p < .05$) was found between the mean coverage ratings of teachers with a good deal of participation in in-service courses and teachers without. The higher mean rating for coverage of topics in basic number concepts being recorded by teachers with a good deal of participation in in-service courses. A significant difference ($p < .05$) was found also between the mean coverage ratings of teachers with O'level mathematics qualification, and those without, the higher mean rating for coverage of topics in basic number concepts being recorded by teachers with no O'level mathematics qualification. With regard to coverage of topics in measurement concepts (Table 6.18), a significant difference ($p < .05$) was found between the mean coverage ratings of teachers teaching in lower primary classes and those teaching in upper primary classes. The higher mean rating for coverage of topics in measurement concepts were recorded by teachers in upper primary classes. In respect of coverage of topics in number operations (Table 6.19), a highly significant difference ($p < .001$) was found between the mean coverage rating of teachers teaching in lower primary classes and those teaching in upper primary. Again the mean coverage ratings, on this occasion for topics in measurement concepts were recorded by teachers in upper primary classes. No significant differences were found between the mean coverage ratings of topics in 'commercial arithmetic and data handling' and 'geometric concepts' presented in Tables 6.16 and 6.17 respectively (see Appendix 6.6(b)).

An attempt was made to explain why the three teacher characteristics - level of teachers' class, teachers' participation in-service, and teachers' O'level GCE qualifications - resulted in differences in the amount of coverage given to topics. Teachers teaching in upper primary classes were found to give more attention to topics in measurement concepts than those teaching in lower primary classes, because most of the exercises on measurement involve units of measurement, finding their equivalencies and carrying out computations on the units, which are taught mainly at the upper primary level. The explanations found for the reasons why teachers with a good deal of participation in in-service courses were found to give more attention to topics in basic number concepts than teachers with little or no participation were trivial and therefore not stated here. This was mainly because about 90 per cent of the in-service courses organised for primary teachers in the period under review were not directed towards the teaching of primary mathematics (see Section 2.6.2).

The mean ratings of coverage of topics in basic number and fractional concepts observed for teachers with O'level GCE qualifications in mathematics, and those without, were 1.79 and 1.76 respectively (see Table 6.16 in Appendix 6.6). The higher mean coverage rating was observed for 53 per cent of the teachers who had no such qualification. No reasons, however, were found to explain why teachers without O'level GCE qualifications in mathematics gave more attention to topics in basic number concepts than their counterparts with the qualifications. But only this will be discussed further in the Chapter 8 because of its implications for the recent campaign launched by the teachers' only professional union, and supported by the Ghana Education Service (see Section 2.6.2), to improve the academic competence of the bulk of school teachers without O'level GCE qualifications.

6.5 Summary

The results presented above indicate that traditional arithmetic topics under numbers and fractions and their operations, which include 'new maths' topics - sets, algebra and points in the number plane, integers and rational numbers - cover about 70 per cent of the content of the textbooks. In the teachers' actual classroom instruction, topics in basic number concepts and number operations categories were emphasised by more than 70 per cent of the teachers. Less than 13 per cent of the teachers indicated topics in these categories as those they hated teaching. Topics or learning tasks under the remaining three categories - measurement, geometry, and commercial arithmetic and data handling, - received only modest attention in both the intended and implemented curricula. It can therefore be argued, in the light of these results, that there is a considerable agreement between the content emphasised in teachers' classroom practice and the content emphasised in the teaching/learning activities prescribed in the official mathematics curriculum materials.

With regard to methods presented in both curricula, the results indicate that the official curriculum emphasises methods that lead to the development of concepts through such processes as counting, classifying, estimating, matching, ordering, re-naming, comparing, describing, and identifying, to mention only a few. But the result of the content analysis of prescriptions in the teacher's handbooks suggests the concepts are to be developed mainly through whole-class teaching where the learners are expected to learn the concepts by reception rather than discovery learning. It was also observed that the instructions in the teacher's handbooks were highly structured towards specific outcomes and no suggestions were offered for alternate options. It was also found that no suggestions for creative work and investigative work were included.

In teachers' actual classroom practice, the results indicate a majority of the teachers failed to use structured teaching materials as well as practical and game activities. They relied solely on textbook routine-tasks. The few who attempted to teach for conceptual understanding and application relied mainly on exposition and taught for reception and not discovery learning. Though more than 90 per cent of the teachers were observed to be able to explain mathematics for pupils to understand, most of them (about 70 per cent) did not encourage discussions in their lessons. Generally, it was observed that skills which are very necessary if pupils are to discover the mathematics they learn were infrequently used. Since the teachers demonstrated little use of such skills, it can be argued that teachers do not intend pupils to encounter what they teach through discovery learning. As it had already been noted that the official curriculum subscribes to the traditional expository teaching method, it can be argued here too that there is considerable agreement between the methods employed in teachers' classroom practice and those prescribed by the official mathematics curriculum.

The test for how differences in teachers, with respect to certain personal characteristics and organisational factors, are likely to influence the teachers' content coverage yielded three significant results. A significant difference ($p < .05$) was found between (a) teachers with a good deal of participation in in-service courses and those without in their coverage of topics in basic number concepts; (b); between teachers with O'level GCE qualifications in mathematics and those without in their coverage of topics in basic number concepts; and (c) teachers teaching in lower primary classes and those teaching in upper primary classes in their coverage of topics in measurement concepts. But as indicated in Section 6.4, only the result concerning O'level GCE qualifications is worth considering because of its implications for assumptions about how to improve primary teachers' efficacy.

CHAPTER 7

RESULTS OF THE ANALYSIS OF THE CURRICULUM

7.1 Introduction

As explained in Section 5.3.5, the curriculum analysis was intended to expose limitations of the curriculum, in terms of its balance, level of complexity and relevance. The curriculum analysis led to two major kinds of evidence– judgmental and observational– which were used to support the researcher's expert rating of the extent to which the curriculum meets major concerns related to the process of cross-cultural adaptation of the curriculum at the education system level. The former exposed mainly data on the content of the curriculum, and the other, the teaching and learning strategies employed. The evidence also exposed specific areas of the official curriculum that required modification.

Seven major cross-cultural curriculum adaptation concerns were examined in the analysis. The list of concerns forming the basis of the analysis, included (as indicated in Section 4.6.3) questions which were considered to have been given insufficient thought during the processes of adaptation. The full list of the cross-cultural curriculum adaptation concerns considered in the analysis can be seen in the curriculum analysis scheme (see Appendix 5.4). In Section 5.3.5, it was explained that the analysis scheme employed in this study required the researcher to put a value (on a three-point scale) on the extent to which the curriculum meets each of the concerns. The presentation of the results, was concluded with the researcher's expert rating[1] of how adequately the curriculum requirements expressed in the concern had been met under current educational provisions in Ghana.

7.2 The content of instruction: its balance and relevance to the educational goals.

In this section, there were two major concerns. The first relates to the consistency of the aims of the curriculum to the overall goals of primary education in Ghana. The second relates to balance in the content in terms of attention given to topics in the five areas of content and the types of mathematical tasks envisaged. The results of the analysis, with respect to these concerns have been presented below.

7.2.1 Are the objectives of the mathematics curriculum as explained in the syllabus, consistent with the overall goals of primary education in Ghana?

The general objectives in the syllabus describe the overall goals of mathematics education at the primary level and are presented in the introductory part of the document. These objectives are

1. To be able to use mathematics in daily affairs by recognizing the situations that require mathematical solutions and the appropriate techniques for solving them.
2. (i) To reason logically.
   (ii) To develop the ability to give explanation based on clear reasons when making decisions.
   (iii) To develop the skill of selecting and applying criteria for classification.
3. To be able to understand events and things as continually changing entities.
4. To understand the process of measuring and to develop an appreciation of the systems and instruments of measurement and to acquire skill in measuring.
5. To develop the basic ideas of quantity, quantitative relationships and numbers, and be able to apply them..

[1] Reason for the use of the researcher's expert ratings can be found in Section 5.3.5.

6. To acquire knowledge of mathematical terms and symbols and be able to think and communicate, using these terms and symbols clearly and correctly.
7. To develop an appropriate, dynamic, and systematic way of solving problems with some definite goals (CRDD, 1988 p5).

It will be observed that none of the seven statements of general objectives, quoted above, suggests an outcome of learning mathematics other than those intended for the development of pupils intellectual or cognitive capabilities. It will be recalled from the second chapter that one of the important aims of including mathematics in the school curriculum at the primary level is to ensure the development of numeracy in pupils. Only the first, fourth and fifth objectives relate to the development of skills that will make pupils numerate. That is, develop the ability to read, write and communicate effectively using mathematics (or numerical, and spatial, concepts). The other four objectives, relate to the development of 'mathematicians' or skills required for the learning of higher mathematics.

These imply the objectives of the mathematics curriculum meet only the first of the six goals of primary education which seeks the development of numeracy and literacy. The emphasis on using *appropriate*, *dynamic*, and *systematic* techniques in solving problems restricts the scope for inquiry and creativity, which is the second of the six goals of primary education. The other four goals which are directed at the development of affective qualities (that is, appropriate attitudes, values, dispositions and sentiments), are hardly covered by the objectives of the mathematics curriculum. There are no indications that the non-cognitive goals or affective goals of education, which Scopes (1973) had described as social, cultural and personal, are important for the pupils' mathematics education.

The 'development of an appreciation of towards one cultural heritage,' which is the third of the six goals of basic education, is not a new theme in mathematics education. Experts like Bishop (1988) and Marcia (1991) have tried to establish that mathematical ideas exist in every culture. Since the individual is to fit into the society, educational opportunities created should, as Bishop (1988) puts it, be in tune with the "home culture" of the learners' society. However, according to Bishop one particular area in the school curriculum where changes to meet the cultural needs of society have been slow is mathematics. To meet such cultural needs, particularly in Africa, Zaslavsky (1973) had devoted a whole book to a range of mathematical ideas that can be found in indigenous African cultural activities such as recreation, language, architecture and craft. The need to investigate first such "indigenous mathematics" in indigenous African culture, and to be able to build effective bridges from it for the introduction of the subject in school, have been corroborated by Gay and Cole (1967). Bishop (1988) argued that the mathematical activities involving counting, locating, measuring, designing, playing, and explaining, are six fundamental activities which are universal because they are carried out by every cultural group ever studied. Notwithstanding the view that the development of mathematical knowledge can be organised around mathematical ideas in these traditional, cultural and universal activities, the provision made in the syllabus for this type of organisation so that pupils can develop a healthy appreciation of their cultural heritage and identity, is extremely limited.

The 'development of the ability to adapt constructively to a changing environment', which is the fourth of the six goals of basic education, is not reflected directly by any of the objectives of the mathematics curriculum stated above. It is true that pupils live in communities in which advances in technology have influenced the mathematical demands of everyday life. For instance, many pupils now own digital watches and the calculator is increasingly being used in carrying out laborious calculations in all walks of life. In spite of the fast changing technology, no mention was made in the official mathematics curriculum materials of the use of such newly emerging everyday tools like calculators, digital watches, and computers. The development of an appreciation of manual work and the sense of citizenship were also not mentioned even though mathematics is one of the crucial subjects in the curriculum whose learning can enhance the development of such qualities. If not confined to only listening and writing activities, mathematics can provide practical experiences for the pupil to work on new and challenging situations often in groups, enabling him or her to relate to others.

It is expected that each of the nine subjects of the primary curriculum provides areas of learning and experiences to meet as many of the goals of basic education as possible. But in the above analysis, it will be realised that the curriculum was designed as though the areas of learning and experiences it was intended for were wholly the development of personal intellectual capabilities. In other words, in provisioning components of the curriculum, the curriculum developers failed to make explicit the need to ensure the subject is used to provide areas of learning and experiences related to the development of (a) creative and imaginative skills; (b) skills required in solving non-routine and real-life problems; (c) personal affective qualities like confidence, perseverance, persistence, working independently, and appreciation and enjoyment of both academic and intellectual work; and (d) social affective qualities, like working cooperatively and relating to others. These make the relevance of the curriculum questionable.

7.2.2 Is the content of the curriculum balanced with respect to the needs of pupils expressed by the overall goals of primary education in Ghana?

The composition of the subject matter content as presented in the textbooks were examined first. The composition of the content was examined under the five areas of content (or topic categories) used in the investigation of the adaptation at the classroom level in Chapter 6.

Basic number concepts are covered by topics in sets and numbers which appear in the opening pages of each year's textbook. They are covered by topics involving kernels in the following areas: recognising, writing and ordering sets and numbers (including fractions) and numerals; recognizing patterns in numbers; place value concepts; and estimation of quantities and rounding off numbers. The concept of number is presented solely as a property of sets. The ordinal and cardinal aspects of number are presented in terms of sets and points on a number line. The ratio aspect of number, however, which is developed with structured materials like Cuisennaire rods, is hardly mentioned in the early years. There are activities involving points on the number-line but these are mainly activities which allow pupils, who have already developed the concept of number and counting, to recognise and compare numbers. The only instances where the ratio aspect of number can be said to have been mentioned were in two activities in the Primary 2 Teacher's Handbook. In these, card board number strips were used to represent number operations in one, and properties of operations in the other (CRDD, 1986b, p20, 26). That is, the activities in basic number concepts were not intended to develop ratio relationship between numbers. Number systems whose elements are natural numbers, whole numbers, integers and rational numbers are also included in this category. These are introduced gradually in the six year course with natural and whole numbers at the lower primary level, and later, integers and then rational numbers at the upper primary level.

Number operations are covered by topics involving learning tasks that are mainly paper and pencil computation presented in isolation (that is, not in context). The development of basic number operations is based mainly on the ideas of the corresponding operations between sets. Number operations include the idea of using symbols (and later on letters) as place holders of numbers that are introduced soon after operations on whole numbers have been taught. The notion of 'operation machine' is suggested here to be used in identifying or spotting number patterns. Learning tasks under these operations machines are however not presented in context and not related to practical activities that lead to number patterns. Mathematical equations (that is, equations and inequalities), which are also in this category, are presented as independent entities to be graphed or solved and hardly as representations of patterns or mathematical relationships. Though mental computation, estimation and reasonableness of solutions are important mathematical strategies here, they are given little attention in the learning tasks in topics covered in this category. The textbooks do not encourage the use of pupils' own methods and the use of calculators for complex computations.

Measurement concepts are covered by topics concerned with measuring or quantifying qualities; and in the primary mathematics curriculum, those qualities are spatial (that is length, area, volume capacity), weight, time and money. Learning tasks in the textbooks for Primary 1 and 2 include activities for intuitive understanding of length, mass and capacity. Learning tasks recommended in topics, in the rest of the textbooks, on measurement, involve mainly units of measurement, finding their equivalencies and carrying out computations on the units. Little is included on the actual measuring and estimation of the qualities mentioned above using both arbitrary and the standard units of measurement.

Geometric concepts are covered by topics that include some traditional (or Euclidean) geometry and the use of vectors and transformations. Though the learning tasks are centred on the notion of points, lines, planes and space, they are developed in an extremely formal and abstract way, much of which involve the recognition of 2-D and 3-D shapes, formal notation in geometry and definitions of terms like ray, line-segment, vertex, congruent, parallel-movement, to mention just a few. The proportion of learning tasks involving informal activities such as building symmetrical patterns, carrying out tessellations, building structures from solids and sketching nets, is rather too low for pupils to build intuitive notions of the geometric concepts. Geometric concepts are covered in the textbooks under: 'Geometry 1' and '2' and Angles.

Commercial arithmetic and data handling concepts, as the name implies, include topics like ratio, proportion, profit or loss, averages, simple interest, rates, descriptive statistics and chance (or probability). Few of the learning tasks on the topics are based on situations that are real to the primary child. Almost all the learning tasks can be described as comprising what is described as routine tasks or standard classroom exercises and the principles involved are developed in a formal and abstract way. The tasks provided are largely concept recognition and skill practice exercises. In exception of chance, where learning tasks involve experimentation, there is no suggestion for non-routine tasks that provide opportunities for pupils to engage in real situations and to apply these principles in context.

The syllabus also covered the content described under the five areas of content presented above. In its introduction part, it indicated that the subject matter content selection should centre around "the development of number concepts and number operations, relationship and measurement, and the concepts of shape, size and space" (CRDD, 1988). The areas around which the teaching of the subject was expected to be centred were described in the syllabus by the curriculum designers as follows:

> "Number concepts ... developed through studies of collections of discrete objects. Both cardinal and ordinal uses of number are included.
>
> The operations ... addition, multiplication, subtraction and division on whole numbers and rational numbers are included. The study of relationships include matching of sets, correspondence and ratio, form, position and quantity;...elementary function, patterns,

> games and puzzles; and pictorial representation. Basic comparisons, e.g. as many as, few, fewer, equal to, greater than, less than....
>
> Measurement ... developed through the use of arbitrary units, estimation of measures, approximation (rounding off) to the realisation of the need for standard measures. The concepts of length, mass, time, money, area, capacity and volume are developed and established through practical activities (experiences). These concepts are reinforced through many more practical experiences of the child with the use of the standard metric measures. (CRDD 1988, p.5).

It can be observed here that no particular reference was made in the syllabus to the 'use of numbers and number operations' or 'applications of mathematics' as an area in itself that is to be studied. This suggests the types of intellectual capabilities the curriculum developers envisage for primary pupils mainly involve the basic number concepts and the computational skills. This can be supported by evidence from the content analysis of the curriculum presented in Section 6.2.1. In terms of textbook pages and textbook exercises, estimates obtained in the content analysis indicated that number operations, which were intended for the development of computational skills, comprised more than half of the content presented in the curriculum and number concepts comprised 20 per cent. Figure 7.1 illustrates the proportion of textbook pages and textbook exercises devoted to the five areas of content.

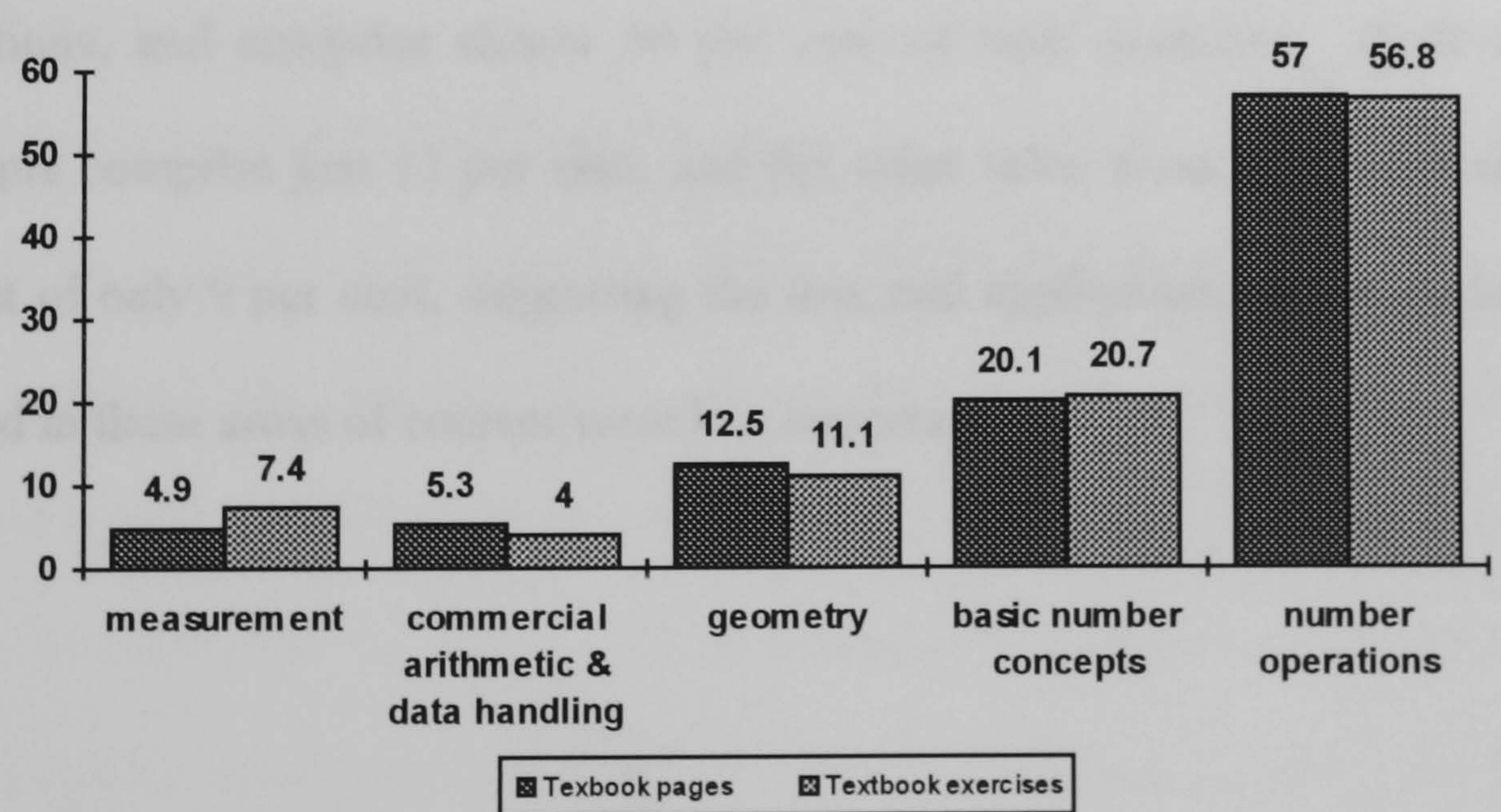

Figure 7. 1 Proportion of textbook pages and textbook exercises devoted to the five areas of content

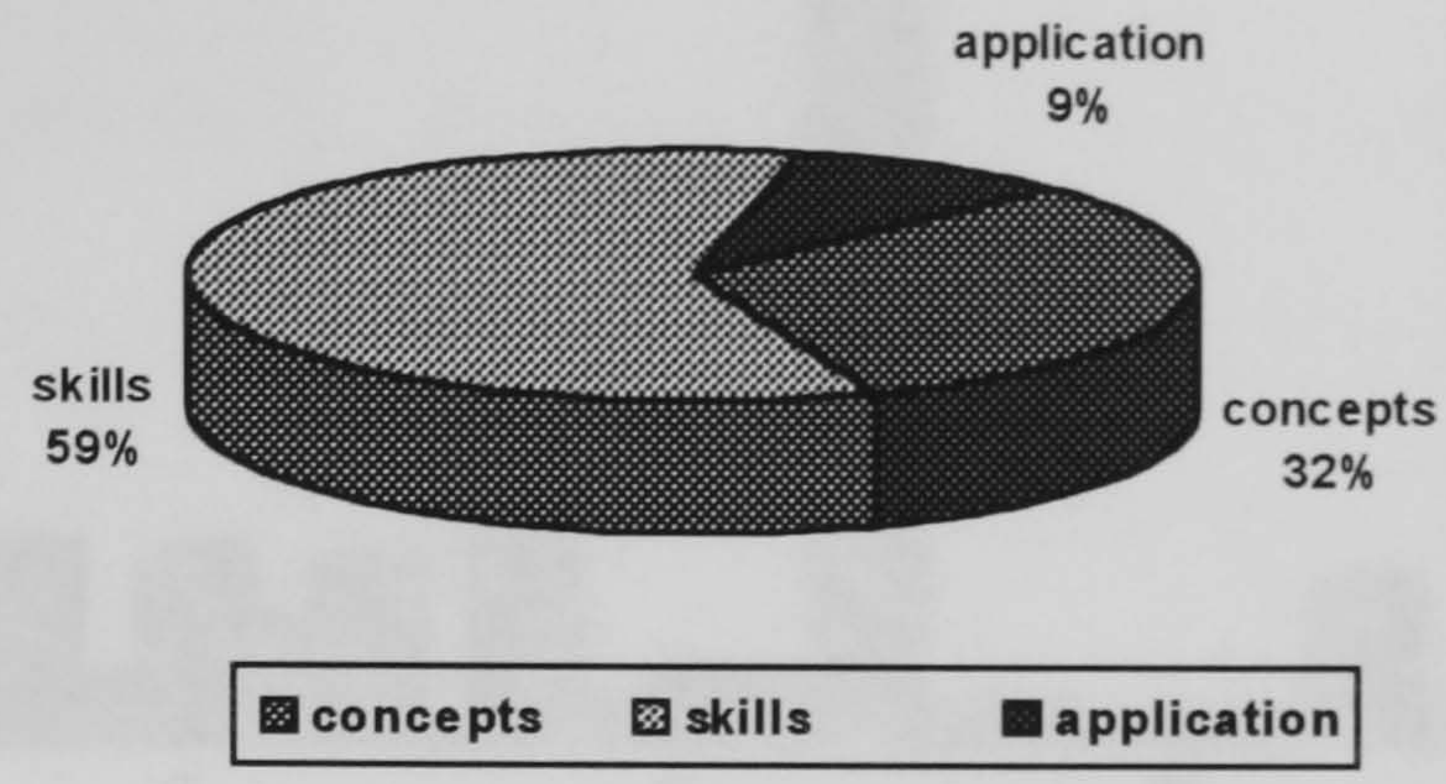

Figure 7. 2 *Proportion of exercises identified as leading to concepts, skills, and applications*

The further examinations of the exercises to see how often the three types of routine exercises– concepts, skills, and applications– occur in the curriculum, indicated clearly the official curriculum's emphasis on the development of number computations and skills involving these. The chart in Figure 7.2 shows that tasks for skills development constituted about 59 per cent of the exercises in the textbooks while applications cover just 9 per cent. Moreover, as presented in Figure 7.3, the few application exercises identified belonged largely to number operations, and comprise almost 80 per cent of such exercises. Basic number concepts comprise just 13 per cent, and the other three areas of content together consist of only 9 per cent, suggesting the use, and application, of the mathematics learned in these areas of content were less important.

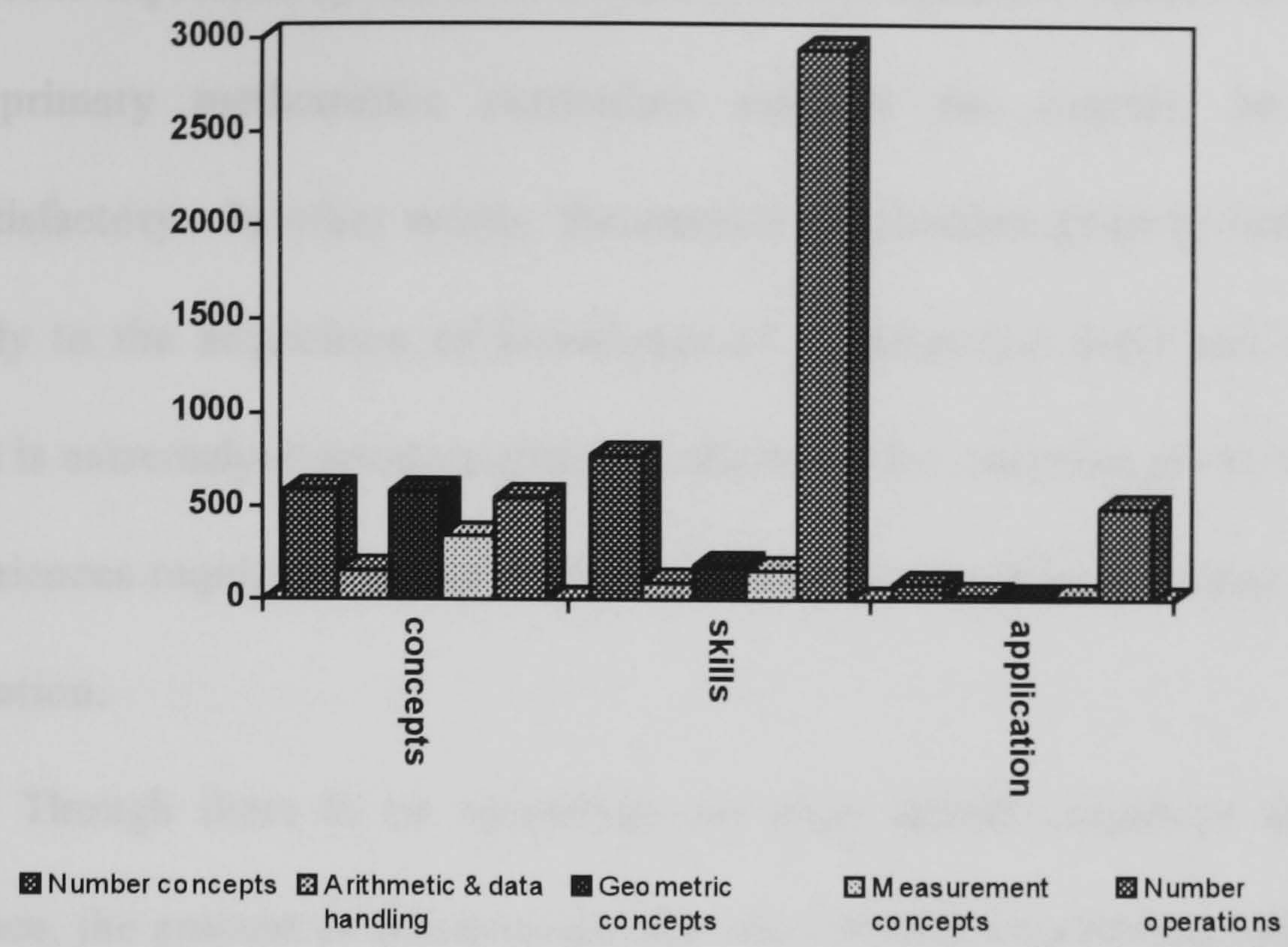

Figure 7. 3 Proportion of exercises identified as leading to concepts, skills, and applications by the topic categories

The report of the Education Commission on Basic Education (MOEC, 1986, p38) pointed out that education should involve "more than providing pupils with knowledge of facts and skills". The commission contends that though these are basic demands, pupils also need learning experiences that will enable them "to think clearly, take initiatives confidently and perform tasks responsibly". The content described above however is devoted mainly to providing pupils with learning experiences that will enable them to acquire knowledge of mathematical facts and computational skills, and not necessarily experiencies that will enable the pupils to encounter the mathematical processes that can lead to the conceptual understanding of the facts and skills. In other words, little emphasis was given to content that will allow pupils to encounter mathematical processes which are necessary if pupils are to develop the conceptual structures that underpin this knowledge. With respect to the needs expressed by the overall aims of basic education, balance in the content of the primary mathematics curriculum can, in this respect, be said to be unsatisfactory. In other words, the amount of attention given to tasks which lead mainly to the acquisition of knowledge of mathematical facts and computational skills is extremely disproportionate in relation to the attention given to the learning experiences required to meet the other needs expressed by the other aims of basic education.

Though there is no agreement on what should constitute an appropriate balance, the amount of attention given to the learning experiences required to meet the needs expressed in the other aims of basic education including creative and imaginative skills; skills required in solving non-routine and real-life problems; personal and social qualities, is apparently low. This suggests the question of balance in the curriculum is also a problematic one.

7.3 Complexity of content and familiarity of methods

7.3.1 Is the language of the pupils' text (length and complexity of sentence, use of foreign words and mathematical terminology, etc.) suitable for the majority of pupils?

This question relates to the first two tasks of Ward's (1973) cross-cultural curriculum adaptation tasks (see Section 3.3). One concerns translation of language, and the other concerns adjusting vocabulary to make reading levels match the abilities of pupils in the educational system for whom the curriculum is being adapted. In the first three years of primary education, the policy on medium of instruction, as mentioned in Chapter 2, requires that pupils in each school are taught mathematics in the local Ghanaian language. This is usually the native language of the majority of pupils in the school. As a result of this policy, the use of the local Ghanaian language, as the medium of instruction, is suddenly terminated in the fourth year, even though by this period the majority of pupils can not express themselves in full sentences in the English language, and have not grasped the mechanics of reading and writing the Ghanaian language.

Though teachers are expected to teach the subject with the numerous new technical (or mathematical) expressions like *union, intersection, addend, integers*, and *segments*, only to mention a few, no *mathematics registers*[2] have been designed in any of the local Ghanaian languages. Moreover, no attempt is made in the teacher's handbooks to differentiate between terminology that is meant for the use of teachers and that which should be used by pupils. Words such as union, disjoint, subset, addend, cardinal numbers and ordinal numbers occur in materials meant for six year olds who are supposed to be learning the subject at this stage in local Ghanaian language. Even though the vocabulary and the legibility of the texts have been adjusted at each stage in the pupils' textbooks, these were done to match the pupils' expected reading levels in English language. Experience has shown that these expected reading levels are however attainable by only a small minority of pupils who have extensive language support at home, and/or pupils who attend

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[2] The term was coined by the linguist Michael Halliday(1975, p65) to describe "the set of meaning that are appropriate to a particualr function of language, together with the words and structures which express the meaning...." In the above context, the register was used to refer to a list of all words in each Ghanaian language and the set of meanings that can be used in the subject to differentiate between their everyday uses and their mathematical meaning.

English-medium schools[3] where the English language is used as the medium of instruction right from the kindergarten. Only a few seven-year olds will find it possible to comprehend, or even read, any of the following questions presented in the first unit of the Primary 2 textbook (CRDD, 1993):

1. Which has more members, set of houses or set of birds?
2. Which has fewer members, set of boats or set of stars?
3. Which has fewer members, the empty set or set of bags?
4. Which sets have exactly the same members?

It can be argued that the presentation of the texts at each stage in the pupils' textbooks were done as if the pupils were going learn the content in the English language and not in the local language. The content was further examined for the level of complexity of mathematical terminology in pupils' texts and their suitability for pupils. As mentioned above, in the textbooks, concepts are presented using their technical or mathematical expressions like *distributive property, solution set, number, plane, rational numbers,* and *rays*, *line-segments*, to mention but only a few. Pupils are required not only to understand these concepts but learn also the technical or mathematical expressions that are in a language other than those they speak. In spite of the differences in the pupils' language backgrounds and the official language in which the textbooks are written, no attempt was made to differentiate between terminology which is meant for the teacher and that which should be used with pupils. For example, exercises meant for seven-year olds on '*commutative*' and '*associative*' properties of addition are presented using these terms as headings in the teacher's handbooks. Generally, it can be said that the

[3] These are the few private international, and preparatory, schools found in urban centres (Chapter 2).

expressions used in the curriculum materials were unnecessarily mathematical even though the concepts could be described much more usefully using everyday language which teachers will find easy when it comes to expressing the ideas in the pupils' local language.

In a paper issued recently by the Ghana Ministry of Education - '*National Programme of Action: Basic Education for All* - it was indicated that

> a picture is emerging form the results of the criterion-referenced tests, and from other evidence, a large number of primary pupils cannot read, nor can they understand simple English that is spoken to them (GMOE, 1994, p51)

Since many pupils cannot read or write English, it can be argued in the light of the difficulties discussed above that the language of pupils' texts in the official curriculum materials is not appropriate for the majority of pupils.

7.3.2 Does the level of complexity of the content asked for in the curriculum materials, fit the ability of the majority of pupils?

The sequence of the content of the curriculum was also examined. The content follows the spiral model. That is, the topics are almost the same throughout the years but increase in complexity from year to year. New concepts together with their numerous and complex associated terminology are introduced too soon and are expected to be taught throughout the years at a pace that is too rapid for the majority of pupils.

Figure 7. 4 Sequence of topics to be covered in geometry from Primary 1 to 6

TOPIC	PRIMARY 1	PRIMARY 2	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6
GEOMETRY	3-D Figures: sorting and describing solid figures :- , sizes, shapes, and surfaces	Geometry : lines, shapes- circles, rectangle, triangle & square- and square- corners	Geometry : lines, shapes, square corners, congruent line- segments, angles and shapes; comparing areas of rectangles	Geometry : lines, shapes- circles, rectangle, triangle , angles; Points and lines: intersections and drawing shapes - 4- sided - 5-sided figures 3-D Figures: sorting and describing solid figures :- , sizes, shapes, & surfaces Intersection of lines and planes in space; identifying vertices, points & lines of intersection	3-D Figures: names and properties : relationship between faces, edges & vertices of shapes; Intersection of lines and planes in space;	Geometry : triangles and quadrilaterals- properties including symmetry and angle sums Enlargements: similarities and ratio applications scale drawing; Parallel, turning and fold movements; Properties of images including symmetries

Take, for instance, the topic geometry, it will be realised from Figure 7.4 that both the sequence of topics and the complexity of learning tasks presented at each year (or class level) in the syllabus increase gradually from the lower (Primary 1-Primary 3) to the upper (Primary 4-Primary 5) primary school years. Thus using formal geometric notations to name lines and figures are introduced by age 8 to 9, and by ages 10 and 11 pupils are expected to be able to determine points in a number plane (expressed in the form [x,y]) which are images of given points in geometric movements including, translations, reflections and rotations.

Also to investigate if Ghanaian pupils will find the curriculum content difficult to learn, the age levels at which topics are introduced in the Ghanaian curriculum were compared with the age levels they are introduced in the curricula in England, and the United States of America. The results are presented in Appendix 7.1. It is evident from the comparison that many topics in the Ghanaian curriculum are introduced at the same age level as in the English and American curricula.

However, several others are introduced earlier in the Ghanaian curriculum than in the English and American curricula. A substantial amount of content is introduced one or two years earlier than in the curriculum for native English speaking children. These topics include fractions, percentages, operations with negative numbers, operations with rational numbers, highest common factors (HCF), lowest common multiples (LCM), formulae for area and volume, using letters as number place-holders, using formal geometric notations, properties of 2-D and 3-D shapes, geometric transformations, points (x,y) in the number plane, and simple interest. In the face of these difficulties, it can be concluded that the level of complexity of the content presented in the curriculum materials is too high for the majority of pupils.

7.3.3 Is there a match between teachers and pupils' expectations and the roles ascribed to them by the teaching and learning activities in the curriculum materials.

The roles which the learning and teaching activities in the curriculum ascribe to teachers and pupils were compared with their expectations and found to be very much alike. The teacher's and pupils' expectations of teaching and learning are, to a large a extent, reflections of the conceptions of teaching held by people in the community in which the teacher is practising. In Ghana, the teacher is seen in most communities as a major resource for learning, and one imbued with knowledge to be transmitted to children. The absence of other viable alternatives or supportive agents of education like the library, radio, television, videos and computers, and the view that, in such circumstances, memory is the only natural means by which information can be acquired and processed, have made the teacher to be regarded as the main source of knowledge for the younger generation. In this capacity, the teacher's role is viewed in the conventional sense of the word *'teach'* as transmission of knowledge (considered in Section 4.4.1). The expected role of the teacher is that of an instructor and the pupils are expected to play an attentive, submissive and passive learner's role.

The analysis of the teaching method emphasised in the curriculum (Section 6.3.1) revealed several roles that the curriculum ascribes to the teacher and pupils as follows:

a) presenting new content mainly through textbook examples/exercises;

b) teaching content which mainly involve mathematical concepts and skills;

c) deciding the pace and nature of classroom activities;

d) teaching new content mainly in whole-class work sessions with occasional individual- or group-work sessions;

e) using mainly *elicit*, and *inform*, exchanges, and discourse patterns that are usually from teacher to pupil and sometimes from teacher to group, and occasionally, their converses;

f) probing for potential misconceptions in the pupils by using carefully chosen examples and non-examples;

g) maintaining an open classroom atmosphere which gives students freedom to ask questions;

and those ascribed to the pupil can be summarised as

h) listening mindfully, and participating in didactic interactions with teacher;

i) responding to teacher's questions, and doing textbook examples/exercises;

j) assimilating rules and procedures and carrying out correct mathematical procedures.

Comparing these roles, it can be argued that there is a substantial match between the roles the official curriculum ascribes to teachers and pupils, and their expectations.

7.4 The curriculum and views on what is currently valued globally in school mathematics

In this section, the content of, and the roles ascribed to the teacher and pupils by, the primary mathematics curriculum in Ghana, was examined in respect of views on what is currently valued globally about the nature of school mathematics.

7.4.1 Does the organisational structure of the content presented in the official curriculum reflect views on what is currently valued globally about the nature of school mathematics?

The organisational structure of the content of the Ghanaian primary mathematics curriculum was examined in terms of three general characteristics – *emphasis in content*, *provisions for differentiation*, and *provisions for cross-curricular links* – shared by current curricula in most countries in Europe and America.

The composition and the organisational structure of the content presented in the official textbooks were compared with that of the curricula currently being used in England and the United States of America. The two reasons which urged the comparison to be made with the curricula of these two countries were both historical. The first was that as a former British colony Ghana had, until the advent of the African (which later became the 'West African Regional') Mathematics Programme[4], used curricula adapted from Britain since independence in 1957. The other is that the African Mathematics Programme was an American initiative and

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[4] The Ghana Mathematics Series (GMS) textbooks and teacher's guides (CRDD, 1986a; 1986b) are products of the WARMP. For more information refer to Chapter 3.

therefore reflected the nature of the curriculum in certain American schools two decades ago. The comparison of the content of the Ghanaian curriculum to that of the American and English curricula showed certain content areas included in the official textbooks which were not covered in the curricular for England and America. The converse was also observed. Thus there were topics taught in England and America which were not included in the official textbooks used in Ghana. Table 7.1 presents a summary of these areas.

Table 7. 1 Content not taught in the Ghanaian, English and American primary mathematics curricula

Content area	Ghana#	England	United States
• Number concepts			
sets of numbers	√		
use of structured aids for number concepts		√	√
approximations and rounding off	√	*	*
• Computational skills			
set notation and operations	√		
mental computations		√	√
• Measurement			
estimation of quantities		√	√
• Geometry			
building symmetrical patterns		√	√
geometric movements	√	*	
• Commercial arithmetic and handling data			
simple interest	√	*	
• Real life applications and problem solving			
non-routine tasks and investigations		√	√
• Use of technology			
calculators		√	√
computers		√	√

#NOTE - A '√' indicates content taught; 'vertical shading' indicates the content not taught at the primary level in the Ghanaian curriculum; and 'horizontal shading' indicates the content not taught at the primary level in the English and American curricula.
'*' indicates content areas where the sources consulted -Howson (1991) and NCTM (1989) - provided no evidence of their inclusion in the curriculum at the primary level.]

It will be recognised from the table that the content in the Ghanaian curriculum has been organised by topics while that of the English and American curricula have been organised by what mathematicians do. Content presented in the latter include the use of structured aids (or manipulatives) for the development of conceptual understanding of number; mental computations; developing a sense of standard measures and estimation of quantities; building symmetrical patterns; using non-routine tasks and investigations in problem solving; and the use of calculators. These topics comprise important mathematical processes which by themselves do not constitute mathematical knowledge but allow pupils to develop their mathematical power and become mathematically literate. The Ghanaian curriculum at the primary level was found to include instead topics such as set theory, estimation and rounding off, simple interest, and geometric movements, which are targeted at specific mathematical or intellectual skills.

There were no suggestions on how concepts and skills can be presented in cross-curricular activities. At this level of education, it is extremely difficult to separately teach the concerns or principles governing basic education like ecological consciousness, self-reliance, fellow-feeling, cultural identity, health consciousness, science and technology and several others, in single subjects. These concerns are more appropriately promoted through topic work, themes and activities involving groups of subjects. Another dimension of cross-curricular issues concern links between, or interdependency of, aspects of the subject and the content offered in different subject areas. Teaching several topics in other subjects depends on work done on certain mathematical concepts. For example, teaching map work in social studies may depend on the pupils' ability to compute and interpret ratios. Teaching pupils to *estimate and cost a meal* in life-skills may depend on the pupils' ability to *plan and check bills.* One typical example of the lack of such cross-curricular considerations in the official curriculum was found in the Primary 5 textbooks for mathematics and social-studies. Though the pupils' first encounter with the concept of ratios was expected to be in the second term of their fifth year (Unit 11 of the mathematics textbook), 'using scales in map work', which depends on the pupils' ability to compute and interpret ratios, was presented as the first unit in the social-studies textbook. Several other instances can be cited where topics in other subjects appear earlier in textbooks than the prerequisite skills or concepts are expected to be taught in mathematics.

Considering the wide ability range of pupils at the primary school level, it was necessary that the official textbooks included adequate guidelines on differentiation. However, no suggestions were made to teachers for providing allowances for differences in the abilities and other characteristics of pupils. The teacher's handbooks contain no advice on how to adapt the chapters to different pupils with varying levels of ability and interest. The handbooks contain no guidelines on how to choose among alternative chapters and activities, and no suggestions for home work (in terms of quantity, types of activities, and the involvement of parents). Though some of the pupils will progress slowly and some will predominantly require a practical approach, teachers are expected to give the same tasks to all pupils and use the same method for all pupils.

The lack of emphasis on mathematical processes, cross-curricular links and guidelines for differentiation, of the Ghanaian curriculum, distances its content from those which have been observed to be used currently in many parts of Europe and America. The content, in these respects, can be said to hardly reflect views on what is currently valued globally about the nature of school mathematics.

7.4.2 Do the roles ascribed to teachers and pupils by the teaching and learning activities in the curriculum match the roles reflected by views on what is currently valued globally in school mathematics?

The instructions in the teacher's handbooks appear to indicate, though not very clearly, that teachers should make pupils learn through activity and not by passive reception of what is taught, and emphasise understanding rather than rote memorisation. The style of lesson presentation in the handbooks stress teaching strategies associated mainly with the structured expository teaching method (see Section 6.3). The main characteristics of this style can be summarised as:

- manipulatives (or concrete teaching/learning aids) are handled by teacher and selected pupils only;
- whole-class teaching is the sole form of classroom organisation and teacher and pupil social interaction is one-way, mainly teacher to pupils and hardly ever pupil to teacher;
- primary school pupils are very much the same in their level of mathematical achievement and therefore do not require individualised instructions;

- mathematics involves accumulation of facts, rules and skills (that is, the products of mathematics); problem solving and applications which involve the processes of mathematics like investigations, experimentation and observations are trivial.
- mathematics develops pupils' cognitive or intellectual abilities mainly through their independent efforts; and hence individual and group work, which allows the development of pupils' enjoyment of mathematics and affective qualities like working cooperatively, perseverance and persistence, have little to offer in the development of mathematical ability.

In Section 7.3, the pupils' and teacher's roles, reflected by the official primary mathematics curriculum in Ghana, were considered. As the roles reflected by views on what is valued globally in school mathematics have been reviewed already (see Section 4.5), it will not be discussed any further here. Nevertheless, how these roles compare to those reflected by the official primary mathematics curriculum in Ghana, have been presented in Table 7.2. The teacher's, and pupils' roles reflected by views on what is currently valued globally in school mathematics indicated in the table are different from those ascribed by the official primary mathematics curriculum in Ghana. The roles reflected by the latter are those that could lead mainly to the acquisition of particular mathematical knowledge. In addition to the acquisition of mathematical knowledge, the roles reflected by the former, could allow pupils to develop confidence in their own abilities, become mathematical problem-solvers and problem-posers, learn to reason and communicate mathematically, and learn to value the subject. The table illustrates a substantial mismatch between roles ascribed to teachers and pupils by the Ghanaian curriculum and roles reflected by what is currently valued in school mathematics.

Table 7. 2 Roles ascribed to teachers and pupils by school mathematics

	Roles reflected by the official primary mathematics curriculum in Ghana	Roles reflected by views on what is valued globally in school mathematics
TEACHER	a) presents new content mainly through textbook examples/exercises.	a) presents new content through context (practical and concrete experiences) using problem situations.
	b) teaches content which mainly involve mathematical concepts and skills.	b) teaches content which mainly involve mathematical applications and problem solving, where concepts and skills are used as tools.
	c) decides the pace and nature of classroom activities.	c) the pace and nature of classroom activities initiated by teacher is dictated by pupils' participation and responses.
	d) teaches new content mainly in whole-class work sessions with occasional individual- or group-work sessions.	d) teaches new content in individual and/or group-work sessions with occasional whole-class work sessions.
	e) using mainly *elicit*, and *inform*, exchanges, and discourse patterns that are usually from teacher to pupil and sometimes from teacher to group, and occasionally, their converses.	e) uses appropriate combinations of *elicit*, *inform*, *direct* and *checking* exchanges, and discourse patterns that varies- pupil to pupil, teacher to pupil (or group) and their converses.
	f) asks if pupils understand rather than probing for potential misconceptions in the pupils by using carefully chosen examples and non-examples.	f) encourages pupils to guess and conjecture and allows them to reason things on their own rather than show them how to reach a solution.
	g) emphasises the use of the official language making the classroom atmosphere one which makes students uneasy to ask questions;	g) maintains a supportive classroom environment which gives students freedom to ask questions and offers appropriate mathematical challenge.
PUPILS	h) pupils listen mindfully, and participate in didactic interactions with teacher;	h) pupils engage actively in problem solving activities, and make their own rules about mathematical principles.
	i) pupils respond to teacher's questions, and do textbook examples/exercises;	i) pupils think and communicate, drawing on mathematical concepts and using mathematical skills; and solve and pose problems.
	j) pupils assimilate rules and procedures and carry out correct mathematical procedures.	j) pupils seek to understand the logic behind mathematical procedures.

7.5 Summary of the results analysis of the curriculum

The results of the curriculum analysis can be summarised as follows:

a) Areas of learning and experiences covered by the curriculum were mainly the development of personal intellectual capabilities; the curriculum did not regard the development of creative and imaginative skills; skills required in solving non-routine and real-life problems; and affective qualities, as important requirements.

b) The curriculum gives too much attention to tasks which lead mainly to the acquisition of knowledge of mathematical facts and computational skills; attention given the learning experiences required to meet the other mathematical needs of basic education - creative and imaginative skills; skills required in solving non-routine and real-life problems; personal and social qualities - is inadequate;

c) The vocabulary and legibility of the texts in the pupils' textbooks match reading levels attainable by only a small minority of pupils, and the complexity of language used was found to be generally above the level of the majority of pupils;

d) In spite of the fact that several mathematical concepts have no equivalent words or expressions in the Ghanaian languages, a substantial number of concepts were found to be introduced one or two years earlier than it is introduced in the curricula for native English speaking children. Thus new concepts together with their numerous and complex associated terminology are introduced too soon.

Furthermore, they are expected to be taught throughout the years at a pace that is too rapid for the majority of pupils.

e) Content in the Ghanaian curriculum has been organised by topics and not by mathematical processes which allow pupils to develop their mathematical power and become mathematically literate; in addition, the curriculum lacks cross-curricular links and guidelines for differentiation distancing its content from what is currently valued globally about the nature of school mathematics.

f) Roles ascribed by the curriculum to teachers are mainly those that lead pupils to the acquisition of 'known or existing' mathematical knowledge, and hardly ever do they lead pupils to form 'new' knowledge and become problem solvers, and therefore do not match the roles reflected by views on what is currently valued globally in school mathematics.

Table 7.3 presents a summary of the results of the analysis involving the seven major cross-cultural curriculum adaptation concerns. The table shows the researcher's expert rating[5] of how adequately the curriculum requirements expressed in the concerns had been met under current educational provisions in Ghana. These results expose weaknesses in the cross-cultural curriculum adaptation process used in the design of the curriculum. In Chapter 8, these weaknesses and their implications for the modification of the curriculum will be considered.

[5] Reason for the use of the researcher's expert ratings can be found in Section 5.3.5.

Table 7. 3 *Extent to which the curriculum meets cross-cultural adaptation concerns*

Cross-cultural curriculum adaptation concerns	Extent to which the curriculum meets the cross-cultural adaptation concern		
	(1) *'Not at all'*	(2) *To a moderate extent'*	(3) *To a great deal'*
1. Are the aims of the curriculum consistent with the overall goals of primary education in Ghana?		√	
2. Is the content of the curriculum balanced with respect to the needs of pupils expressed by the overall goals of primary education in Ghana?	√		
3. Is the language of the pupils' text (length and complexity of sentence, use of foreign words and mathematical terminology, etc.) suitable for the majority of pupils?	√		
4. Does the level of complexity of the content asked for in the curriculum materials, fit the ability of the majority of pupils?	√		
5. Is there a match between teachers and pupils' expectations and the roles ascribed to them by the teaching and learning activities in the curriculum materials			√
6. Does the structure of content presented in the official curriculum reflect current thinking about the nature of school mathematics ?		√	
7. Do the roles ascribed to teachers and pupils by the teaching and learning activities in the curriculum match the roles reflected by views on what is currently valued globally in school mathematics?		√	

CHAPTER 8

CONCLUSIONS AND DISCUSSIONS

8.1 Introduction

The mathematics schemes currently being used in Ghana - the *Ghana Mathematics Series* (GMS) textbooks and Teacher's Handbooks (CRDD, 1986a, 1986b) - were products of curriculum projects in Africa which were strongly influenced by the 'new math' movement. The series were first published between 1975 and 1977 by the Ghana Ministry of Education. In Chapter 1 it was revealed that concerns have been raised internationally for countries still using schemes which are products of such projects to adjust their mathematics curricula (Howson and Wilson, 1986 p.14). Besides, educational authorities in the country have expressed great concern for the low pupil achievement in mathematics at the primary school level. However, little had been done to make the materials suitable for the majority of both pupils and teachers. A 'criterion referenced test' organised recently found that less than 10 per cent of pupils are able to achieve mastery of between 40 and 55 percent of the content presented in the official mathematics curriculum (GMOE/PREP, 1994). Thus the mastery level of the content of the curriculum for the majority (i.e. about 90 per cent) of primary pupils is below 40 per cent.

Unaware of the limitations in the adaptation process of the curriculum materials at the national level, educational administrators at the Ministry were quick to accept claims that poor performance of primary pupils in the subject was due to deficiencies in the teachers' ability to teach the content of the materials. Official documents obtained from the Ministry claim that most primary teachers cannot use the prescribed methods and are not confident and competent enough to facilitate the learning of mathematics in the primary school. This claim could have been justifiable in the early years of the curriculum change (that is, the last half of the 1970s). However, the fact that the 'new math' schemes, which came with the innovations, have remained in schools for almost two decades makes it less likely that unfamiliarity of content has led to deficiencies in the teachers' instructional practices. The failure to move the primary mathematics curriculum away from positions adopted between 1960 and the early 1970s, and poor attainment in the subject in the nation's primary schools, had provided the original spur to the study. Before beginning to summarise the results obtained, it would be helpful to look briefly at the issues examined and methods employed in examining them.

8.2 The investigation and limitations of the study

The investigation addresses issues related to the nature and appropriateness of the official primary curriculum in Ghana, and whether, or not, teachers are able to translate it into reality in the classroom. The study was based on the model introduced in Chapter 1. The model presents the school curriculum as one that can be viewed from three perspectives - intended, implemented and attained - which are associated with three separate levels in the school system - education system, classroom, and pupil. Two separate sets of intentions were considered for the intended curriculum - intentions expressed by the overall goals and principles governing primary education; and intentions expressed by the objectives, and teaching/learning activities, in the official mathematics curriculum materials. The study involved an investigation of the extent to which the content prescribed by the educational system is actually taught by the teacher at the classroom level. The results of the extent of correspondence between the curricula at the educational system, and classroom, levels provided evidence to verify whether the low pupils' attainment in the subject is really a reflection of teachers' inability to teach a substantial part of the content of the curriculum. The study also involved an investigation of the coherence between the two sets of system level intentions, and finally, explored the influence of certain teacher characteristics and organisational factors on teachers' coverage of the subject matter content of the mathematics curriculum. Since the literature reviewed revealed that only a few studies have been conducted on the influence of teacher characteristics and organisational factors on teachers' subject matter content coverage, and also because factors other than those examined in this study were involved in those studies, this final aspect of the investigation, which involved influence of certain teacher characteristics and organisational factors on teachers' content coverage, was purely exploratory.

The principal questions that were examined in the investigation were stated in Chapter 5. They include (a) Is the coverage of content in teachers' instruction different from the coverage of content recommended in the official curriculum? (b) Are the teaching methods emphasised by the teaching and learning activities in the official curriculum different from the teaching methods employed by teachers in its implementation? (c) Which teacher characteristics and organisational factors influence the extent to which teachers cover topics in the mathematics curriculum at the classroom level? (d) What is the structure, content and complexity of the current official primary mathematics curriculum, and what are its strengths and weaknesses? (e) Are the requirements of, and provisions in, the official primary mathematics curriculum coherent with the overall educational goals of basic education in Ghana?

The methods employed in answering these questions were based on two assumptions. One concerns the use of the degree of correspondence between sets of curricula intentions within the educational system level as a measure of efficiency of the school system (Livingstone, 1985). The other concerns the use of the degree of correspondence between the intended and implemented curricula as a measure of curriculum adaptation at the classroom level (Smylie, (1994); that is, it is concerned with finding a measure of teachers' ability to teach content, and employ methods, prescribed by the official primary mathematics curriculum. Underpinning these assumptions is the view that a substantial part of what is covered by each of the aspects of the curriculum should correspond when considered both within the system level and between the three curriculum levels of the school system (see Figure 1.3). This view suggests that if the overlap between the aspects of the curriculum is not substantial, then there are inefficiencies in the educational system.

Measures of content coverage identified in the literature (McDonald, 1976; Good et al. 1978; Barr, 1987; Freeman and Porter 1989), which include such proxies for content coverage as counts made of concepts presented, time allocated to content, and textbook length or number of pages in textbook devoted to concept or topic, were used to determine the extent of coverage of subject matter content presented in both the intended and implemented curricula. Coverage of methods was conceived as related to how often teachers employ different teaching skills, classroom organisational patterns and classroom discourse patterns, associated with either the traditional expository or discovery teaching styles. Teachers' use of the discovery teaching method in their classroom practice was examined in terms of - 'how often teaching skills that increase the chances of the pupils' discovery' - were used in instruction. Counts of words in the official syllabus related to processes associated with the three stages of mathematical activity - concepts development, skills development, and application of concepts - were used to examine the official curriculum's emphasis on discovery methods. Furthermore, the proportions of instructions on teaching activities in the teacher's handbooks suggesting the three common forms of classroom organisation (whole class, individual, and small group); and the proportions of instructions presented in teacher's handbooks as well as teachers' actual instruction suggesting the four common classroom-exchange types (elicit, inform, direct and checking), were used to examine the official curriculum's emphasis on discovery methods.

The methods employed in this study have a number of limitations. The first is, no account was taken of how effectively teachers can use teaching methods, and present content, prescribed in official curriculum materials. That is, the units of analysis employed in the study did not also measure how well teachers' coverage of teaching methods and subject matter content have actually influenced pupils' attainment. The units were used to measure only the extent of coverage and therefore the results must be treated with caution in drawing conclusions regarding how effectively the curriculum is implemented. The second limiting factor concerns the use of research assistants to rate teachers' use of selected teaching skills. The raters' skills in identifying the 'relevant teaching skills in teaching situations' and their skills in determining the criteria for rating teachers' frequencies of using the teaching skills' was crucial. Training was, of course, provided to the raters in this regard (see Section 5.3.2), though it would have been better if the researcher had been able to do it all by himself.

The third limitation concerned the task of classifying textbook exercises in terms of types of mental activities in the content analysis. The task, which involved identifying the types of mental activities - conceptual learning, skill development and application - that the textbook exercises were intended to generate, was not an easy and straightforward one. It was not always easy to tell if a given mathematical task was intended to lead to the conceptual learning of a new principle, or to the development of a new computational technique. However, this observation is not particularly relevant to the purposes of this aspect of the study, as the level of mental activities so obtained were used only to describe the objectives and nature of the exercises prescribed by the official curriculum.

Another limitation was the reliance on the expert judgment of the researcher in the curriculum analysis which was used to expose the degree of correspondence between the two sets of curricula intentions within the educational system level. Reasons for relying solely on the researchers' judgmental evidence has been stated elsewhere (see Section 5.3.5). Though based on judgmental evidence, the subjective observations made brought out areas within the school system where there was little or no correspondence between the intentions presented in the official mathematics curriculum and the overall goals of primary education. The conclusions drawn by the observer on this curriculum analysis must therefore also be treated with caution.

The final limiting factor, intrinsic to the methods used in the study, was the district-based case study approach employed. About a third of the teachers in the Winneba District were involved in the study. Ideally, the findings should be applicable, to a large extent, in all primary schools in the Winneba District. Furthermore, since the Winneba District is typical of districts in the entire country (see Section 5.2) the results of the study can be taken as a fairly good representation of situations in mathematics teaching in Ghana. However, there is always a danger in drawing conclusions from limited samples.

8.3 Summary of findings

8.3.1 Content taught and content learned in the official primary mathematics curriculum in Ghana

The study has shown that all teachers taught the topics in basic number concepts and number operations, which comprise more than 70 per cent of the content of the official curriculum and include most of the 'new math' content. About 75 per cent of the teachers were found also to emphasise these content areas in their instruction. Additionally, the content areas of geometry, measurement, and commercial arithmetic and data handling, where topics were not taught by a considerable proportion of teachers (up to 30 per cent of them), were found to constitute just about 30 per cent of the content of the official curriculum.

These results suggest a substantial part of the curriculum is taught by the teachers, and therefore the low pupils' attainment obtained in the CRT in all content areas cannot be a reflection of what teachers really teach in the curriculum.

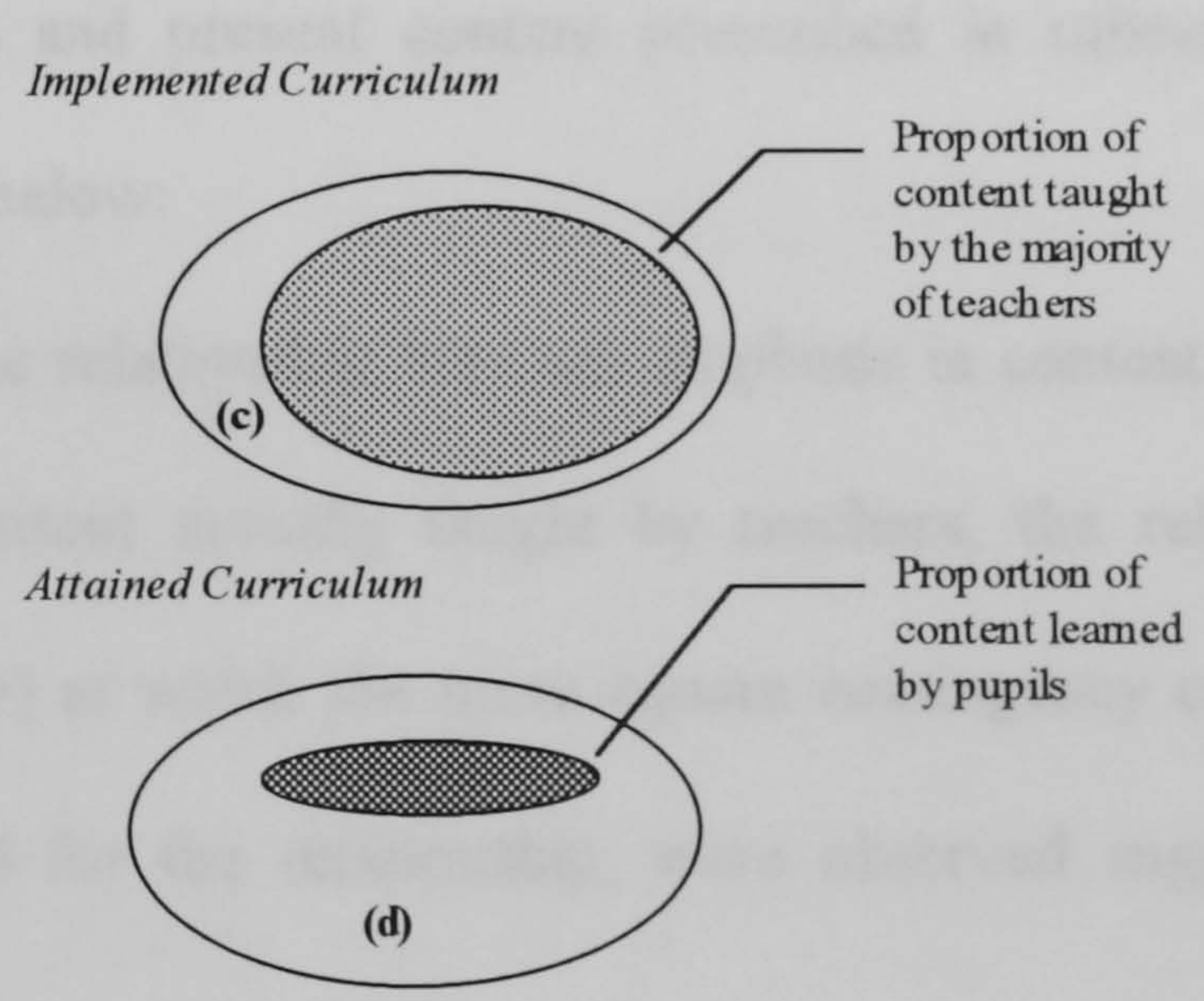

Figure 8. 1 Relationship between content taught and content learned in the official primary curriculum in Ghana

If it is put in the context of the framework presented in Figure 1.2, the results can be represented by the illustration in Figure 8.1, which depicts a situation in the curriculum where what the teachers really teach in all content areas are far in excess of the content that the pupils are successful in learning. In this context, it can be said that the results confirm a disparity between these two levels of the curriculum which manifests inefficiencies in the school system.

8.3.2 The between level correspondence of the intended and implemented curriculum

The study found that inefficiencies in the school system were not due to the teachers' inability to adapt the curriculum at the classroom level as claimed by the educational authorities. That is, the inefficiencies were not due to a massive lack of correspondence between the intended and implemented curricula. The findings on the extent of curriculum adaptation at the classroom level, including how well teachers can use methods and present content prescribed in official curriculum materials, are summarised below:

i. with regard to the relationship between emphasis in content presented in the textbooks and the content actually taught by teachers, the relatively small significance levels ($p < 0.5$) at which the mean square contingency coefficients of 0.49[1] and 0.47[2], obtained for the relationship, were observed suggest the two

[1] $p = 0.014$ was the observed significant level associated with this contingency coefficient.

[2] $p = 0.035$ was the observed significant level associated with this contingency coefficient

variables are dependent. This implies the coverage of textbooks does influence the emphasis on topics presented in teachers' instruction.

ii. in terms of the relative amount of attention given to topics, no significant difference was found between the emphasis in the content taught by the primary school teachers and the emphasis in the content presented in the official curriculum;

iii. teaching methods prescribed in the official curriculum materials require teachers to develop mathematical concepts mainly through whole-class teaching so that the learners are expected to learn the concepts by reception rather than discovery learning;

iv. teaching methods predominantly used by teachers in their classroom practice involve mainly expository teaching skills; teaching skills which are very necessary if pupils are to discover the mathematics they learn, are used infrequently.

The first result suggests a positive relationship between the emphasis on the content prescribed by the official curriculum and the content actually implemented by teachers. The relationship can be seen clearly in the graph presented in Figure 8.2 [where the proportion of teachers emphasising the topic categories are compared with estimates of coverage of the official curriculum based on counts of textbook pages and syllabus objectives].

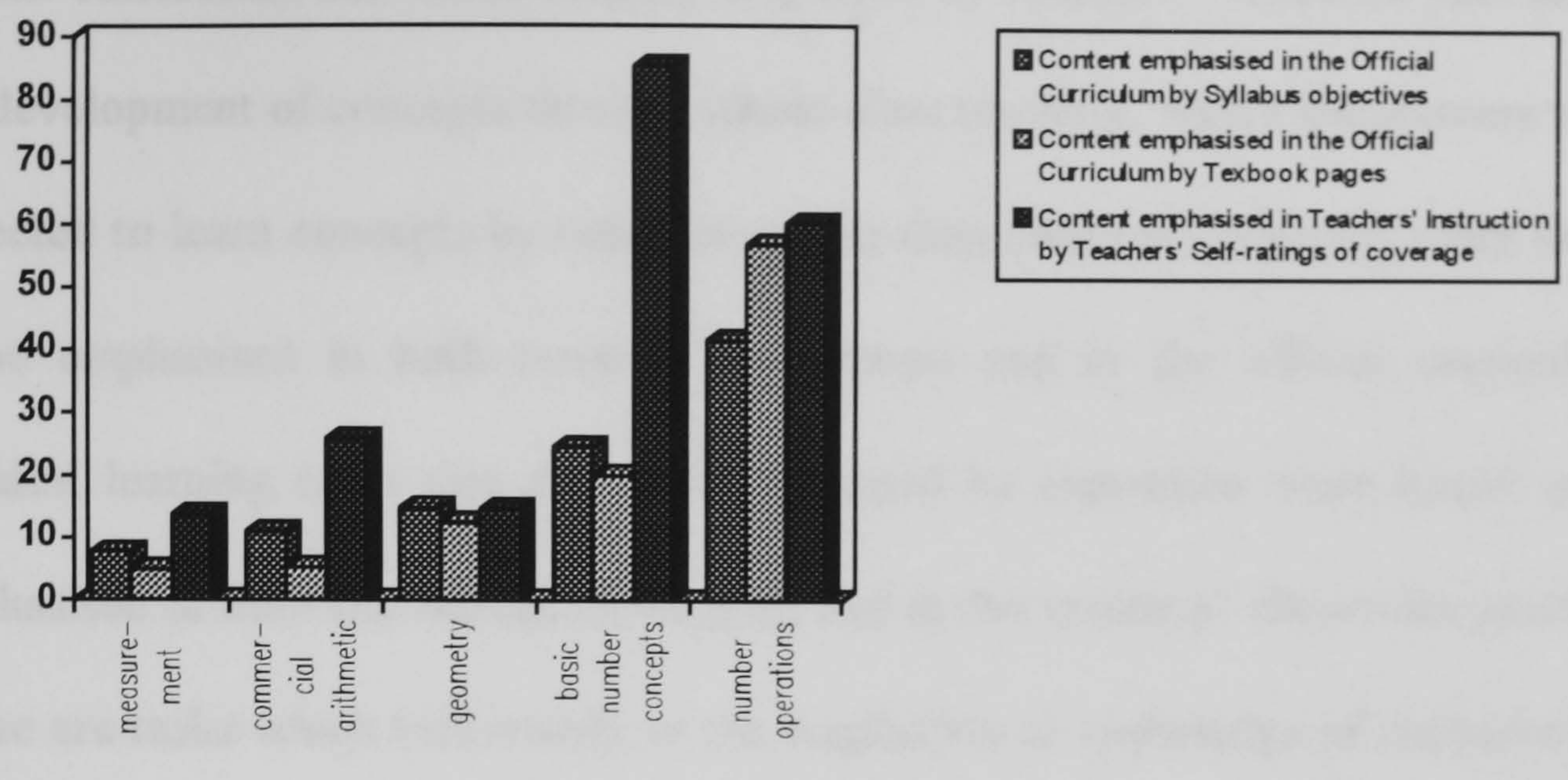

Figure 8. 2 Extent of coverage of topic categories in the official curriculum and in teachers' instruction

The columns in the graph show that topics in basic number concepts and number operations, which are the most emphasised in the official curriculum, are also those that are most emphasised by teachers. Similarly, topics in measurement and statistics and data handling which are the least emphasised in the official curriculum are also the least emphasised in teachers' classroom practice. The results, as indicated by the graph, corroborate Travers and Westbury's (1989) earlier observation that topics in arithmetic (which are classified in this study under basic number concepts and number operations) are the most emphasised in the mathematics curriculum at both the system and classroom levels in education systems throughout the world.

The second result suggests topics covered in the textbooks are most likely to be covered in teachers' instruction, and topics emphasised in the textbooks are most likely to be emphasised in teachers' instruction. The third and fourth results indicate there is a considerable match between the methods prescribed by the official curriculum and those actually employed by teachers. Methods that led to the development of concepts through whole-class teaching, where the learners were expected to learn concepts by reception rather than discovery learning, were found to be emphasised in both teachers' instruction and in the official curriculum. Besides, learning tasks that are easily presented by exposition were found to be emphasised in both the official curriculum and in the teachers' classroom practice. These are tasks which lead mainly to the acquisition of knowledge of mathematical facts and computational skills. Tasks that require methods involving practical work and investigations were hardly used. These therefore suggest that the textbook is an important factor in determining what is taught, and how it is taught, in the classroom. Besides, as Porter *et. al.* (1988) observed a decade ago of teachers in the United States, the results indicate that both the official curriculum and teachers in Ghana agree in their emphasis on learning tasks that involve mainly computational skills over those that lead to concept development and applications.

Although both the teachers and the official curriculum emphasised the expository teaching method, it was found that because of problems with the language of instruction and lack of resources, most teachers had difficulties in using teaching skills that are vital in making their expository teaching 'structured or systematic' (Rosenshine and Stevens, 1986). For example, the majority of the teachers do not ask a large number of questions; they neither check for student understanding, diagnose for weaknesses, nor provide remedial help. The attributes of the teaching method emphasised in both the official curriculum and teachers' instruction can be summarised as follows

- conceptual understanding and skill development are the major mental processes involved in learning mathematics at the primary level; applications (or mental processes which allow the concepts and skills learned to be applied) are regarded as unimportant;
- new content is presented mainly through teacher demonstrated activities in whole-class work sessions with occasional interruptions with individual- and/or group-work sessions;
- the teacher initiates all classroom activities, and classroom discourse includes mainly elicit, and inform, exchanges;
- the pupils' role is to listen mindfully and participate in didactic interactions with teacher.

8.3.3 The within system level correspondence of the intended curriculum

On realising a considerable agreement between the content emphasised at the classroom level and the content emphasised in the teaching/learning activities prescribed by the official mathematics curriculum, the two sets of system level intentions (or the aspects of the curriculum designated (a) and (b) in the framework - Figure 8.3) were examined for any mismatches that might cause inefficiencies in the school system. It was found that there is a lack of correspondence within the intended curriculum (that is, between aspects (a) and (b) of the curriculum). Thus the intentions of the official mathematics curriculum to provide for pupils' needs does not map exactly onto the intentions emanating from pupils' overall mathematical needs expressed by the goals and aspirations of the education system. The results of the curriculum analysis, presented in Chapter 7, indicated a number of shortcomings of the official primary mathematics curriculum which have been summarised below:

- it places too much emphasis on the acquisition of 'known or existing' mathematical knowledge - facts and computational skills -;
- it makes no provisions for the development of creative and imaginative skills, skills required in solving non-routine and real-life problems, as well as affective qualities;
- the content has been organised by topics and not by mathematical processes which can allow pupils to develop their mathematical power and become mathematically literate;
- it provides no guidelines for differentiation, and cross-curricular links which allow mathematical concepts to be used in context;
- the vocabulary and legibility of the texts in the pupils' textbooks match reading levels attainable by only a small minority of pupils, and the complexity of mathematical language used is generally above the level of the majority of pupils;
- new concepts together with their numerous and complex associated terminology are not only introduced too soon, but are also expected to be taught throughout the years at a pace that is too rapid for the majority of pupils.

8.3.4 Influence of O'level GCE qualification in mathematics on teachers' content coverage

The test for how differences in teachers (with respect to certain personal characteristics and organisational factors) are likely to influence their content coverage yielded three significant results. But as indicated in Section 6.4, only one of the results is worth considering. This concerned the difference between teachers with O'level GCE qualifications in mathematics, and those without, in their coverage of topics in basic number concepts. The analysis showed a significant difference ($p < 0.05$) between teachers with O'level GCE qualifications in mathematics and those without in their coverage of topics in basic number concepts. But no significant differences were found between the two categories of teachers in their coverage of the remaining areas of content (see Appendix 6.6). It showed that teachers without O'level GCE qualifications in mathematics gave more attention to teaching topics in basic number concepts than teachers with the O'level GCE qualifications in the subject. These results suggest O'level GCE qualification in mathematics does not make any significant impact on teachers' coverage of content of the primary mathematics curriculum.

The results are not however surprising because the content of the O'level examination is not identical to the content of the primary mathematics curriculum. The content of the former is not only complex but also include several topics which are not included in the primary curriculum. Besides, my personal observation of courses organised at the *GCE O'level Centres* (see Section 2.6.2) indicated that the activities at the centres, as the name suggests, were all geared toward the examination. The content of the courses were never designed to cover primary curriculum matters and pedagogical issues, and the course organisers at the centres did not teach in ways in which teachers are expected to teach pupils at the primary level. Basic number and fractional concepts do not only comprise topics which are emphasised in the curriculum but also include concepts and skills whose understanding are paramount for the effective learning of the content of the entire curriculum. They include the concepts of sets, numbers and place value, and skills like recognising, writing and ordering sets, numbers (including fractions) and numerals; recognizing patterns in numbers; estimation of quantities; and rounding off numbers. They also include the concept of the number system whose elements are natural numbers, whole numbers, integers and rational numbers. Bearing all this in mind, and also that the two categories of teachers were not significantly different in their coverage of the remaining areas of content, the findings have implications for the usefulness of O'level GCE qualifications in improving the teaching of mathematics.

These results have implications for the recent campaign launched by the teachers' only professional union, and supported by the Ghana Education Service (see Section 2.6.2), to improve the academic competence of the bulk of school teachers without O'level GCE qualifications. Since teachers without O'level GCE qualifications in mathematics gave more attention to topics in this important area of content than their counterparts with the qualifications, but did not differ very much from them in their coverage of the other areas of content, the assumption that the teaching of the subject will improve when teachers obtain O'level GCE qualifications is doubtful.

O'level GCE qualifications on their own lead mainly to general (or academic) attainments in the subject which, as the results have indicated, make little difference in the primary teachers' content coverage. If the O'level GCE qualifications were intended to make the teachers increase the amount of attention they gave to areas of content of the primary curriculum which were given inadequate attention in the curriculum (geometry, measurement, and commercial arithmetic and data handling), then as the results indicate, it has failed to do so. But there are no clear-cut guidelines with regard to the direction in which the O'level GCE qualification is expected to improve classroom practice. There is therefore a need to make explicit how the qualification is expected to enhance practice so that courses are organised in that direction.

Therefore in an educational system, like the one in Ghana, where teachers possess low teaching qualifications, it would be useful if courses are planned rather to increase the teachers' knowledge about the pedagogy of primary mathematics and provide them with opportunities to analyse the curriculum for lack of balance in its coverage as well as the difficulties that are likely to cause the lack of balance. The Ministry of Education should therefore consider altering the academic nature of the courses offered by the O'level GCE centres so that courses which will emphasise the development of teachers' pedagogical knowledge and professional skills are provided. It will be helpful if such courses will lead to qualifications which will be comparable to the O'level GCE qualifications. The Ministry of Education may also consider devising a "qualification" that will accord teachers a status which is equivalent, in terms of salary, to O'level GCE qualification. The content of the examination that will lead to this qualification should include some general mathematics but constitute mainly primary mathematics teaching methods.

8.4 Conclusions and Caveats on findings

In terms of the framework presented in Chapter 1, the results can be represented by the illustration in Figure 8.3.

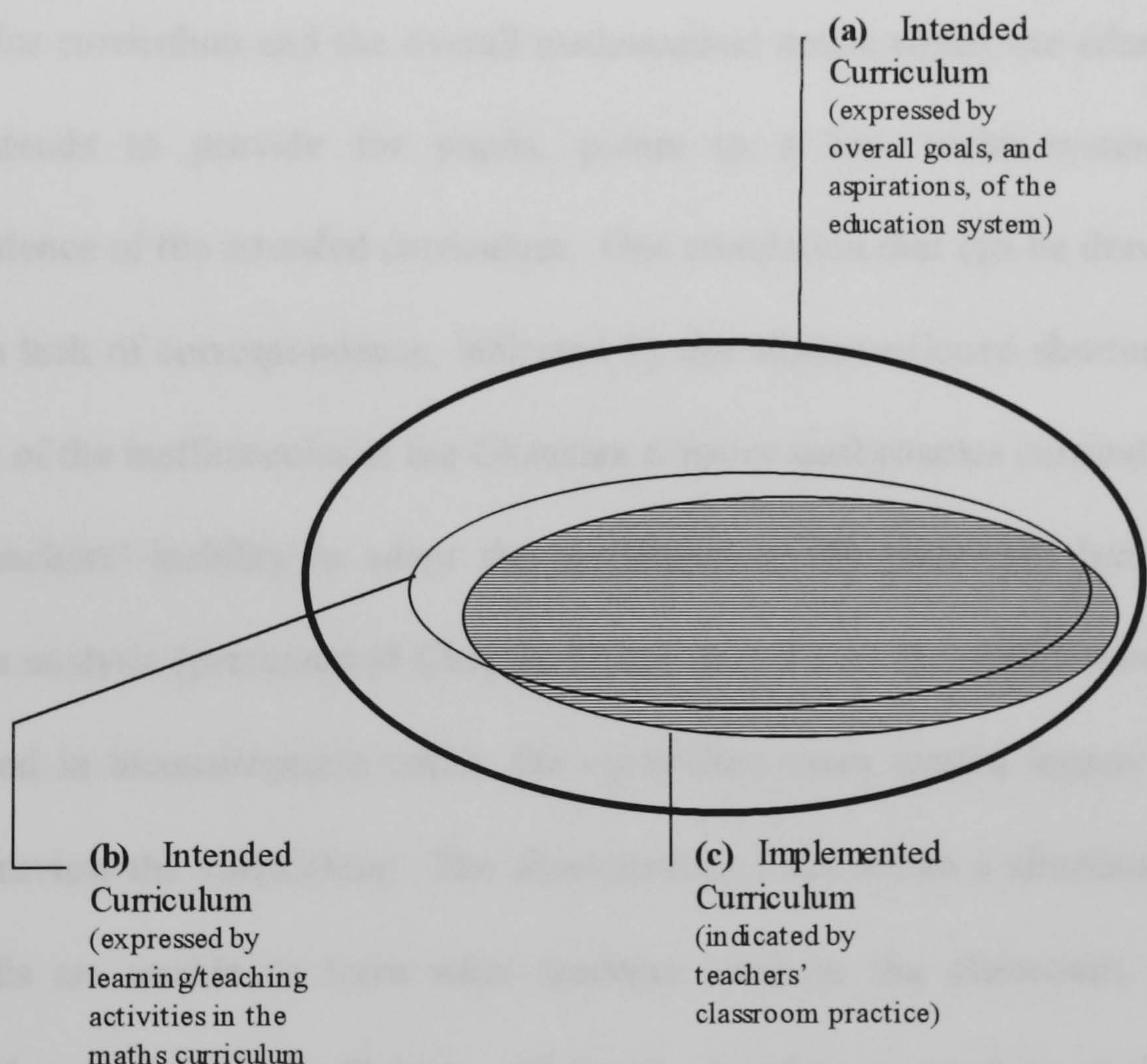

Figure 8. 3 Relationships between content taught and content intended by the official primary curriculum in Ghana

The figure depicts a situation in the curriculum where there is a substantial agreement between (c) - what the teachers really teach - and (b) - the learning and teaching activities prescribed in the official mathematics curriculum materials. However, neither (b) nor (c) are adequate enough to meet the full requirements of (a) - the mathematical needs of pupils which the curriculum is intended to provide for at this level of education. Therefore based on these findings, it can be argued that the inefficiencies in the primary mathematics curriculum, in schools in the Winneba District, and very likely the whole country, cannot be blamed wholly on the teachers' inability to adapt the curriculum at the classroom level.

Nevertheless, the lack of match between the intentions of the official mathematics curriculum and the overall mathematical needs which the educational system intends to provide for pupils, points to a low within-system level correspondence of the intended curriculum. One conclusion that can be drawn here is that this lack of correspondence, indicated by the aforementioned shortcomings, is the root of the inefficiencies in the Ghanaian primary mathematics curriculum and not the teachers' inability to adapt the curriculum at the classroom level. The curriculum analysis (presented in Chapter 7) has shown that the shortcomings that had resulted in inconsistencies within the curriculum were caused largely by the failure to review the curriculum. The shortcomings have led to a situation where most pupils are unable to learn what teachers teach in the classroom, and so rendered the curriculum inefficient. There is therefore a need to review the curriculum to make sure the two system level intentions are consistent.

The assertion that the CRT was based on syllabus objectives (see Section 1.1), meant the CRT results were comparable to the learning and teaching activities prescribed in the official mathematics curriculum materials, and not to what the teachers really taught. In this regard, one will be making an error in evaluation if one takes the CRT results as a reflection of the teachers' ability to adapt the curriculum at the classroom. It will be wrong to conclude on the basis of the CRT that the reform had failed to make pupils realise most of the mathematical needs which the curriculum intends to provide for them because a closer study of the test might reveal the syllabus objectives (on which it was based) lacked content balance and therefore could not be used as a valid measure of all the mathematical needs which the curriculum intends to provide for pupils. This points to an important caveat to evaluators of educational systems. In assessing how successful a reform in an educational system is in meeting the mathematical needs which the system intends to provide for its pupils, evaluators must exercise a good deal of caution in using only particular test results as the measure of what pupils actually learn.

The general guidelines on the delivery of the curriculum at the system level recommend that teachers should use investigational or activity methods which are directed towards learning tasks which will encourage inquiry, creativity, and manipulative and manual skills (see Section 2.7). But in explaining these methods to classroom teachers, mathematics curriculum implementers (training college and secondary school mathematics teachers and mathematics organisers in GES District and Regional offices) in the country tend to confuse them with those intended to induce learning by discovery. This confusion is due partly to the rhetoric on the use of teaching skills that suggest the discovery method in the introductory part of the curriculum materials, and partly to the frequent use of the word- *discover*- in stating teaching objectives of the content prescribed in the syllabus and teachers' handbooks. Nevertheless, the results of the investigation of the adaptation of the curriculum at the classroom level revealed that both the official curriculum and the teachers who implement it emphasised the expository teaching method. This suggests the curriculum designers may not have intended the discovery method to be used in its implementation, or may not have appreciated how it might be used. The rhetoric on the use of the discovery method in the official curriculum materials must therefore be interpreted with great caution.

The literature review (see Chapter 4) has indicated that teachers are generally conservative with regard to curricular change, and are most receptive to proposals for change that fit with their classroom procedures and did not cause major disruptions (Doyle and Ponder, 1977). It has also indicated that research has not convincingly shown that any pattern of teaching behaviour leads consistently to better learning (Kilpatrick, 1978). Bearing these in mind, and also the suggestion of Guthrie's (1990) that the teaching process in schools, particularly in developing countries, can be improved by helping teachers to improve the traditional expository styles, it will not be efficient to expect teachers to shift radically to the discovery teaching method, given that both the official curriculum and the teachers emphasise the expository teaching method.

As the rhetoric on the use of teaching skills that suggest discovery methods were found not to be backed by learning/teaching activities that lead to discovery learning, it can be argued that there is a lack of match between the intentions of the mathematics curriculum and the actual learning/teaching activities prescribed. This mismatch between the intentions and the actual learning/teaching activities is one manifestation of the lack of 'within-system coherence of the curriculum. The lack of coherence of the curriculum within the system level is also manifested in the absence of guidelines in the mathematics curriculum on the use of learning tasks which will encourage inquiry, creativity, and manipulative and manual skills or tasks which will encourage the use of investigations (see Section 2.7). Since teachers' classroom teaching methods cannot be changed overnight, and can hardly be changed if the curriculum materials intended to guide their classroom behaviours have not been modified, these results call for a major review of the curriculum.

8.5 Recommendations and suggestions for future research

For teachers to be successful in translating into reality the learning/teaching activities prescribed by the mathematics curriculum, there is a need to review the official mathematics curriculum to provide a coherent curriclum and to creat a curriculum which will be possible to implement. It will be very useful if experts who have good understanding of the lack of within-system and between-system level correspondence of the curriculum carried out the review. On the one hand, the review must ensure the rhetoric about teaching methods in the curriculum materials matches what is prescribed for actual classroom practice. On the other hand, it should make the actual classroom practice, prescribed by the teaching/learning activities in the materials, consistent with the system level guidelines which require the use of investigational or activity methods. It should also enable mathematics curriculum implementers in the country to realise that expository teaching can also involve investigational or activity methods so that inquiry, creativity, and manipulative skills can be acquired also through reception learning activities.

If teachers had held higher teaching qualifications as well as higher qualifications in mathematics, the curriculum could be said to be appropriate for them. But since the schools are staffed with teachers with low teaching qualifications or even no qualifications, the proposal of helping teachers to improve their traditional expository styles should be given serious consideration in the review of the curriculum. One way that this can be done is through in-service education and training initiatives. I would therefore like to recommend that in-service education initiatives must be directed at helping teachers to use expository teaching skills that will allow pupils to meaningfully learn what is taught in the classroom rather than shifting radically to the use of the discovery teaching method. To do this, teachers can be helped to use *structured activities* and *lesson episodes*.

Structured activities comprise learning/teaching resources that provide learners with the opportunity to see not just the mathematical principle (or rule) to be learned but also their attributes which will allow them to determine whether or not the rule can be applied when the conditions are varied in similar situations. A lesson episode, on the other hand, allows the mathematical principle (or rule) not to be learned in isolation, but to be encountered in context or real situations in which the principle is conceived to exist. In the lesson scenarios described in Chapter 4, Mrs. Addo made use of structured activities, while Mr. Boboobe used a lesson episode. Since teaching methods that allow teachers to use structured activities and lesson episodes have been discussed elsewhere (see Chapter 4), they will not be considered any further.

In Section 5.3.2, it was mentioned that raters' used in this study were provided with training in skills required in identifying relevant teaching skills in teaching situations. One lesson that I learned during this process is that teachers become critical and open about the shortcomings of their teaching methods after watching (or listening to) others teach in real class situations (and/or in tape-recorded lessons) and discussing their observations. In the light of this, initiatives to improve teachers' classroom methods should include tasks that will encourage teachers to sit in the lessons of other colleagues. They should also include showing teachers video-tapes (or playing audio-tapes if the video will be too expensive) of lessons which are carefully planned and taught in normal classroom settings to illustrate expository teaching skills that will lead to meaningful learning, and those that will not. After watching these tapes, teachers should be given the opportunity to discuss the methods. The tape-recorded lessons that will illustrate expository teaching skills that lead to meaningful learning should enable teachers to see clearly. how they can do the following:

* use a language of instruction that will allow the pupils to express their views and ask questions in class;
* ensure classroom discourse is appropriately balanced between elicit, inform, direct, and feedback exchanges; and
* use lesson episodes and present real life experiences of the mathematical concepts and skills taught;
* engage pupils in mathematical tasks that will allow the concepts and skills they learned to be applied in context;
* balance whole-class work sessions with individual- and/or group-work sessions.

If the nation had not been pursuing educational policies directed at making primary education universal, and making education relevant to the changing needs of all pupils of school going age (see Chapter 2), the primary mathematics curriculum could be said to be appropriate for the pupils. Furthermore, recommendations in recent reports to review or overhaul the syllabus and textbooks (see Section 2.8) provided no detailed suggestions to guide the proposed reviews. The results of this study however, suggest that the review of the curriculum should go beyond re-writing the textbooks and teachers' handbooks to meet international standards, and revising the mathematics syllabus to allow basic skills to be presented before more advanced skills and knowledge are introduced. They suggest a need for experts, who have good understanding of what should constitute an appropriate within-system and between-system level correspondence of the curriculum, to review the curriculum to ensure that what the official curriculum prescribes and the teaching/learning activities it prescribes for actual classroom practice are consistent with the system level guidelines which require the use of investigational or activity methods. The results of the curriculum analysis (see Chapter 7) will be found to be useful, in this regard, in ensuring that there is coherence within the curriculum at the system level, and in bringing about an appropriate correspondence between the various levels of the curriculum. In the light of these results, I would like to submit, in addition to the above, the following recommendations for consideration in the review of the content of the curriculum:

- a *supplementary teacher's handbook* with lesson episodes that will promote the development of skills required in solving real-life and non-routine problems should be written, published and supplied to all teachers. Taking account of the power of the textbook in determining what is taught and how it is taught, it is likely that the textbook and teacher's handbook will remain a major resource in the classroom. Therefore developing a supplementary teacher's handbook which will introduce teachers to an extensive repertory of strategies may be the most effective way of ensuring more active and effective learning in the classroom. Teachers will be more likely to integrate lesson episodes into their teaching if they are put into an official curriculum material than merely demonstrated in in-service courses.

- the supplementary teacher's handbook should provide guidelines on how teachers can determine whether or not pupils' have reached the cognitive threshold that is necessary for a successful transfer of the medium of instruction from the Ghanaian language to the official language (English), and how the transfer can be efficiently done. This is essential because, as indicated in Section 7.3, by the beginning of the fourth year, when teachers are expected to switch from the use of the local Ghanaian language as the medium of instruction to the use of English, the majority of pupils cannot express themselves in full sentences in the English, have no grasp of the mechanics of reading and writing the Ghanaian language; and above all, cannot read the mathematics textbooks.
- lesson episodes in the proposed supplementary teacher's handbook must be organised in a way that will promote the development of affective qualities, like confidence, perseverance, persistence, working independently on new and challenging situations, and working cooperatively and relating to others. They should also allow the teacher the flexibility to organise lessons around mathematical processes, and not always by topics (as in the case of the textbooks).
- in addition to the key steps for the development of the mathematical concepts and skills in the original teacher's handbooks, the proposed supplementary teacher's handbook must include
    - more learning tasks on actual measuring and estimation of qualities - length, area, volume capacity, weight, time and money - using both

arbitrary and the standard units of measurement, and guidelines on how to use such activities to provide context for developing basic number concepts including the ratio relationship between numbers;

* guidelines to change the emphasis on the formal and abstract way in which geometry in taught to the use of informal learning tasks that involve activities such as building symmetrical patterns, producing and using tessellations, building structures from solids and sketching nets;
* suggestions for real life experiences (or lists of examples) which can help to give meaningful context to the mathematical kernels, and common difficulties which pupils are likely to encounter and how these might be overcome;
* suggestions on how the learning of mathematical concepts and skills can be promoted through cross-curricular activities in topic, theme, and project work;

- *workbooks* should be written to accompany the textbooks for all the primary classes. The *worksheets* in the proposed workbook should be
  * graded so that the complexity of tasks, vocabulary and legibility of texts, match reading levels attainable by all abilities, and
  * collated and carefully ordered so that pupils can use the workbooks as they progress along the primary classes, at their own pace;
  * organised in a way that will make it easy for the teacher to prune and re-organise content in the textbooks for a range of classes (but not to rely

solely on the textbook meant for a particular class). This is to ensure that pupils are presented with content which match their abilities since a substantial number of concepts were found to be introduced in the textbooks one or two years earlier than it is introduced in the curricula for native English speaking children.

The research has involved several complex issues regarding the official Ghanaian primary mathematics curriculum and the way it is implemented in an educational system which failed to move its primary mathematics curriculum away from positions assumed in the light of the 'new math' innovations of the 1960s and early 1970s. The conclusions drawn have been based on data that had been descriptive and largely judgmental. The study has only been able to provide a sharply focused picture of the intended curriculum and match between this and the implemented curriculum. In addition to highlighting the characteristics of the two curricula, the study points to promising directions for future research. One fruitful direction of further research that the study points to is to investigate the match between the implemented curriculum and the attained curriculum, that is, between teachers' coverage and what is actually learned by pupils. This will expose topics on which pupils' performance is low but are given substantial coverage (or opportunity to learn) by teachers. A second direction for future research is to identify factors influencing the correspondence between the implemented and attained curricula. To ensure that pupils are successful in learning what is actually taught by teachers in all content areas of the curriculum. researchers following this direction must investigate questions like:

a) What instructional time should be allocated to each topic that is taught?

b) Given that the medium of instruction in lower primary schools is the pupils' local Ghanaian language, should all topics in the curriculum at this level be retained and taught to all pupils irrespective of their home backgrounds?

c) To what standards of achievements should pupils be held for each topic?

It is important that researchers following this direction move beyond methods that lead mainly to descriptive and judgmental data on teachers' classroom practice to consider case study approaches. In such approaches, systematic descriptions of the teachers' coverage (including the actual instructional time allocated to each topic) can be obtained through daily teacher-logs for a whole academic year.

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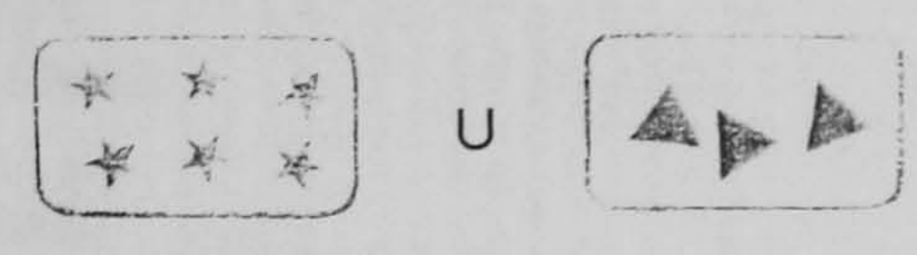
APPENDICES

Appendix 1. 1Extracts of texts from the 1975 edition and the 1986 edition of the GhanaMathematics Series textbook scheme

Page 11 of the first (or 1975) edition of the textbook for Primary 3 (i.e., for 8 to 9 year olds)

Jnit 2

1.

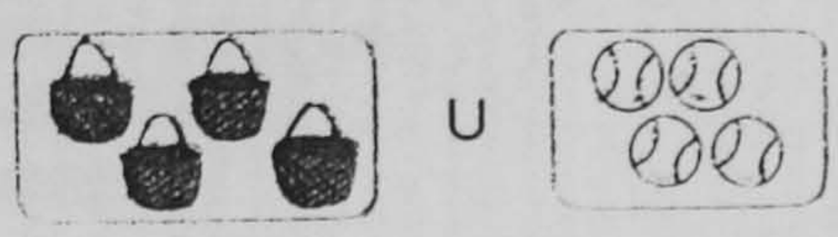


________ + ________ = ________

The addends are ____ and ____.

The sum is ____.

2.



________ + ________ = ________

The addends are ____ and ____.

The sum is ____.

Unit 2

Addition Sentences

1. 2+3 = ☐	21. ☐ = 7+9
2. ☐ = 0+7	22. 12+5 = ☐
3. 2+7 = ☐	23. 4+12 = ☐
4. ☐ = 3+8	24. ☐ = 0+10
5. ☐ = 3+13	25. ☐ = 7+10
6. 9+9 = ☐	26. 16+3 = ☐
7. 13+4 = ☐	27. 9+7 = ☐
8. ☐ = 12+6	28. 8+5 = ☐
9. 6+2 = ☐	29. 10 = 7+☐
10. 4+7 = ☐	30. ☐+9 = 10

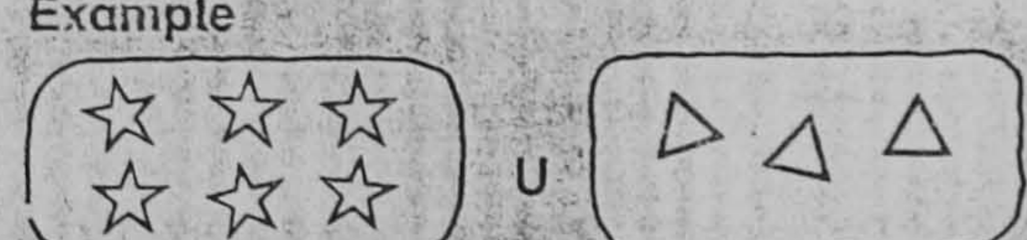
Page 11 of the reviewed (or 1986) edition of the textbook for Primary 3 (i.e., for 8 to 9 year olds)

UNIT 2

Union of sets and addition

Complete the sentences.

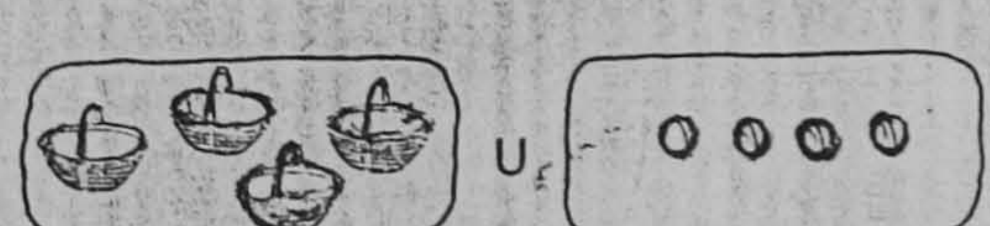
Example



6 + 3 = 9

One addend is the number of stars – 6.
The other addend is the number of triangles – 3.
The sum is the stars and the triangles put together – 9.

1



.... + ... = ...

The addends are .... and ....
The sum is ....

Addition sentences

UNIT 2

Find the missing sums and addends.

Examples

2 + 1 = $\boxed{3}$ The missing sum is 3.
3 + $\boxed{2}$ = 5 The missing addend is 2.

1 2 + 3 = ☐	21 ☐ = 7 + 9
2 ☐ = 0 + 7	22 12 + 5 = ☐
3 2 + 7 = ☐	23 4 + 12 = ☐
4 ☐ = 3 + 8	24 ☐ = 0 + 10
5 ☐ = 3 + 13	25 ☐ = 7 + 10
6 9 + 9 = ☐	26 16 + 3 = ☐
7 13 + 4 = ☐	27 9 + 7 = ☐
8 ☐ = 12 + 6	28 8 + 5 = ☐
9 6 + 2 = ☐	29 10 = 7 + ☐
10 4 + 7 = ☐	30 ☐ + 9 = 10

Appendix 1. 2Mathematical concepts and skills in which pupils' performed poorly in the Criterion Referenced Test.

use of <and>
rounding numbers
fractions on the number line
adding simple fractions - different denominator
adding mix fractions
subtracting mixed fractions
two basic operations on whole numbers
basic operations on money
area of a rectangle
area of a plane region
prime numbers
renaming fractions
changing fraction to decimals
changing decimals to fractions
quantities in given ratios
changing common fractions mixed fractions
changing fractions to percentages
ordering decimal fractions
operations on integers
solution sets
graphs of sentences
points in a plane
dividing 2 - and 4 - digit numbers vertically
subtracting simple fractions - different denominator
multiplying using mixed fractions
dividing using mixed fractions
perpendicular lines
changing units of area

dividing simple fractions
adding decimals horizontally
subtracting decimals vertically
subtracting decimals horizontally
multiplying decimals horizontally
dividing decimals by powers of 10
dividing decimals vertically
finding least common multiples (l.c.m.)
volume of a rectangular prism or cube
changing percentages to fractions
finding percentages of quantities
expressing quantities as percentages
expressing ratios in simplest form
dividing

identifying quantities in proportion
finding prime factorisations
expressing a quantity as a percentage
percentage increase or decrease
direct proportions
converting units of length or distance
basic operations on volume
basic operations on time
averages
simple interest
chance
sum of the angles of a triangle

[SOURCE: List was issued by the GES representative of the Primary Education Project (PREP) to the resource personnel who were in charge of the 'training of trainers' in-service programme in Kumasi in August 1992]

Appendix 2. 1 Timetable for Primary Schools Suggested by the Basic Education Division of the GES [Source: Winneba GES District Office]

Day	Class	8.00 - 8.10	8.10 - 8.15	8.15 - 8.45	8.45 - 9.15	9.15 - 9.45	9.45 - 9.55	9.55 - 10.25	10.25 - 10.55	10.55 - 11.25	11.25 - 11.35	11.35 - 12.05	12.05 - 12.35
	1			Mathematics	Mathematics	Physical educ.	B	English lang.	Ghanaian lang.	Writing	B	Ghanaian lang..	Cultural studies
M	2	A		English lang	English lang	Mathematics	R	Mathematics	Ghanaian lang.	Ghanaian lang..	R	Life skills	Life skills
O	3	S	R	Mathematics	Mathematics	Physical educ.	E	English lang.	Ghanaian lang.	Science	E	Science	Cultural studies
N	4	S	E	Mathematics	Mathematics	Physical educ.	A	English lang.	Ghanaian lang.	Ghanaian lang..	A	Science	Science
	5	E	G	Mathematics	Mathematics	Ghanaian lang.	K	English lang.	English lang.	English lang.	K	Social studies	Life skills
	6	M	I	Mathematics	Mathematics	Physical educ.		Cultural studies	Cultural studies	English lang.		Ghanaian lang.	Life skills
	1	B	S	Mathematics	Social studies	Ghanaian lang..	B	Cultural studies	English lang.	English lang.	B	Agric/gardening	Agric/gardening
T	2	I.	T	Science	Science	Physical educ.	R	Ghanaian lang..	Social studies	Writing	R	Agric/gardening	Agric/gardening
U	3	Y	R	Mathematics	English lang.	English lang.	E	Ghanaian lang	Social studies	Social studies	E	Agric/gardening	Agric/gardening
E	4		A	English lang.	English lang.	Physical educ.	A	Mathematics	Life skills	Life skills	A	Science	Science
	5		T	Mathematics	English lang.	Mathemati	K	Science	Science	Ghanaian lang.	K	Social studies	Life skills
	6	A	I	Mathematics	Mathematics	English lang.		English lang.	Life skills	Life skills		Ghanaian lang.	Life skills
	1	S	O	Mathematics	Mathematics	Ghanaian lang	B	Life skills	English lang.	Social studies	B	Agric/gardening	Agric/gardening
W	2	S	N	Mathematics	Mathematics	English lang.	R	English lang.	Ghanaian lang.	Life skills	R	Cultural studies	Agric/gardening
E	3	E		Mathematics	Ghanaian lang	English lang.	E	Physical educ.	Ghanaian lang.	Cultural studies	E	Life skills	Life skills
D	4	M	R	Mathematics	English lang.	Cultural studies	A	Social studies	Social studies	Science	A	Science	Ghanaian lang..
	5	B	E	English lang.	English lang.	Physical educ.	K	Ghanaian lang..	Ghanaian lang..	Agric/gardening	K	Life skills	Writing
	6	L	G	Mathematics	Science	Science		Ghanaian lang.	Life skills	Life skills		Cultural studies	Writing
	1	Y	I	English lang.	English lang.	Physical educ.	B	Cultural studies	Science	Life skills	B	Life skills	Agric/gardening
T	2		S	Mathematics	Mathematics	Physical educ.	R	English lang.	English lang.	Life skills	R	Cultural studies	Science
H	3		T	Mathematics	Mathematics	Science	E	Social studies	Life skills	Life skills	E	Cultural studies	Agric/gardening
U	4	A	R	Mathematics	English lang.	English lang.	A	Life skills	Life skills	Life skills	A	Cultural studies	Social studies
	5	S	A	Mathematics	Cultural studies	Science	K	Life skills	Life skills	Life skills	K	Cultural studies	Social studies
	6	S	T	English lang.	English lang.	Physical educ.		Cultural studies	Agric/gardening	Social studies		Social studies	Science
	1	E	I	Mathematics	Mathematics	Ghanaian lang	B	Life skills	Life skills	Cultural studies	B	Games	Games
F	2	M	O	Social studies	Social studies	English lang.	R	Science	Life skills	Cultural studies	R	Games	Games
R	3	B	N	English lang.	Elementary sci.	Social studies	E	Ghanaian lang	Writing	Cultural studies	E	Games	Games
I	4	L		Mathematics	Social studies	Social studies	A	Cultural studies	Agric/gardening	Agric/gardening	A	Games	Games
	5	Y		Mathematics	English lang.	Science	K	Cultural studies	Agric/gardening	Agric/gardening	K	Games	Games
	6			Mathematics	English lang.	Cultural studies		Cultural studies	Agric/gardening	Agric/gardening		Games	Games

Appendix 2.2 Table of the content of the primary mathematics curriculum manifesting the spiral approach

TOPIC	PRIMARY 1	PRIMARY 2	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6
SETS	Sets & Pre-number work; Numbers with sets;	Reviewing numbers with sets	Comparing, ordering, and combining sets of numbers	Sets of numbers: natural , integers , factors, multiples, prime, square	Sets of numbers	Sets of numbers
NUM-BERS AND NUMERALS	Numbers: 1-5, & 0; 6-9, & 10. Place value & numbers 10 - 99	Place value and 3-digit numbers: 100 - 999	Place value and 4-digit numbers: 1000 - 9 999	Roman numeral system; Hindu-Arabic numeral up to 99 999	Numerals up to 999 999; LCM & HCF; Number games with sets of numbers	Numerals exceeding 1 000 000; More LCM & HCF ; Indicies
OPERATIONS ON NUMBERS	'+' & '-' with sums: 0-9;then 10-100; Applications: money problems (mechanial)	'+' & '-' with sums up to 1000; multiplication and division by 2,&3; Applications : money problems (mechanical)	'+' & '-' with sums up to 9 999; multiplication and division by 2,3,4, &5; Operation machines; Applications: problems in measurement (mainly money);	The 4 arithmetic operations; Estimations; Operation machines; Applications : problems in measurement (mainly money); Rounding off numbers	Harder arithmetic operations and applications. Rouning off numbers	Harder arithmetic operations and applications. Rounding off numbers
PROFIT & LOSS					Profit and loss, cost price & selling price; word problems	Profit and loss, cost price & selling price; word problems; profit & loss percent
FRACTIONS & RATIONAL NUMBERS	Recognition of halves and quarters	Recognition and counting in halves, thirds, fourths and eighths	Comparing and ordering fractions ; equal fractions	Decimal and per cent names for simple fractions	More fractions and their decimal & per cent names	Harder fractions and their decimal & per cent names; Percentage increase and decrease
OPERATIONS ON RATIONAL NUM-BERS			Adding and subtracting like vulga fractions	Addition, and subtraction, of vulga, decimal & percent fractions; multiplication by fractions and division by whole numbers ; Word problems	Rational numbers : vulga, decimal & percent fractions; multiplication by rationals and division by integers Estimations and approximations; Word problems	Further rational numbers- vulga, decimal & percent fractions-multiplication by rationals and division by integers; Estimations and Approximations; Word problems
INTEGERS				Integers on the number line; Addition and subtraction of integers; Word problems	Integers : more addition & subtraction; multiplication and division by whole numbers; Word problems	Integers : more addition & subtraction; multiplication and division by integers; Word problems
RATIO & PROPORTION					Comparing and simplifying ratios	Sorting equal ratios, proportion and inverse proportion; Word problems
INTEREST						Simple interest on savings (I = PRT)

GRAPHS			Collecting data, drawing and reading graphs - block, and pictograms	Collecting data, drawing and reading graphs - block, bar and pictograms	Collecting data, drawing and reading graphs - block, bar , line and pictograms	Graphing data - pie charts, bar and line graph; Interpreting data
AVERAGES					Averages: mean , median and mode	Averages: mean , median and mode
LENGTH	Measurement of length - comparing lengths with arbitrary units	Measurement of length - comparing lengths with metre- units and centimetre-units	Measurement of length - measuring with metre-units and centimetre-units	Measurement of length - measuring perimeters in centimetres; Change of measurements;t he 4 operations with measurements	Measurement of length- Problems in change of measurements and the 4 operations with measurements	Measurement of length- Problems in change of measurements and harder problems on the 4 operations with measurements
CAPACITY	Measurement of capacity - comparing containers with arbitrary units	Measurement of capacity- comparing containers with litre-units	Measurement of capacity- measuring with litre-units	Measurement of capacity- measuring in litres and centilitres; Change of measurements;t he 4 operations with measurements	Measurement of capacity- Problems in change of measurements and the 4 operations with measurements	Measurement of capacity- Problems in change of measurements and harder problems on the 4 operations with measurements
VOLUME				Measurement of volumes- filling with unit-cubes ; making cubes	Measurement of volumes- calculating volume of cubes and cuboids	Measurement of volumes- calculating volume of prisms and cylinders
WEIGHT	Measurement of weights- comparing containers with arbitrary units	Measurement of weights- comparing containers with litre-units	Measurement of weights- measuring with litre-units	Measurement of weights- measuring in litres and centilitres; Change of measurements;t he 4 operations with measurements	Measurement of weights- Problems in change of measurements and the 4 operations with measurements	Measurement of weights- Problems in change of measurements and harder problems on the 4 operations with measurements
AREA			Measurement of areas - tilling with unit-squares - rectangles ;	Measurement of areas - tilling and finding areas with centimertre-square units; drawing regions with given units	Measurement of areas - triangles; calculating areas of triangles and rectangles; Word problems	Measurement of areas - triangles and circles; calculating areas of circles, triangles and rectangles; Word problems
TIME	Measurement of Time - reading clock by hours	Measurement of Time - reading clock using : half, quarter, past and to	Measurement of Time - reading time by hours and fractions of an hours; Calculations with these and years, months, weeks & days,	Measurement of Time - reading time by hours and minutes; Calculations with these and years, months, weeks & days,	Measurement of Time - reading time by hours and minutes; Calculations with these and years, months, weeks & days; word problems	Measurement of Time - reading time by hours and minutes; Calculations with these and years, months, weeks & days; word problems
ANGLES			Making and identifing angles: congruent and right angles	Measurement of angles : finding and comparing angle sizes using arbitrary unit angles	Measurement of angles : drawing and finding angles 90 degrees or < using protractor;	Measurement of angles : drawing and finding angles at a point using protractor;

EQUATIONS AND GRAPHING SOLUTION SETS					Solution sets: linear equations & graphs on number; linear inequations & graphs on the number plane	Solution sets: linear equations & graphs on number; linear inequations & graphs on the number plane
PLANE GEOMETRIC FIGURES		Geometry : lines, shapes- circles, rectangle, triangle & square- and square-corners	Geometry : lines, shapes, square corners, congruent line-segments, angles and shapes; comparing areas of rectangles	Geometry : lines, shapes- circles, rectangle, triangle , angles; Points and lines: intersections and drawing shapes - 4-sided - 5-sided figures	Geometry : Points and lines: intersections and drawing shapes; Special triangles and properties; symmetry and circle parts	Geometry : triangles and quadrilaterals- properties including symmetry and angle sums
SPACE GEOMETRIC FI-GURES	3-D Figures: sorting and describing solid figures :- , sizes, shapes, and surfaces			3-D Figures: sorting and describing solid figures :- , sizes, shapes,& surfaces Intersection of lines and planes in space; identifying vertices, points & lines of intersection	3-D Figures: names and properties ; relationship between faces, edges & vertices of shapes; Intersection of lines and planes in space;	
MOVEMENT GEOMETRY						Enlargements: similarities and ratio applications &scale drawing; Parralell, turning and fold movements: Properties of images including symmetries
CHANCE						Concept of probability with simple experiments : dice, coin, and choosing from a set of objects, etc.

Appendix 5. 1 The Political Regions of Ghana

Appendix 5. 2Basic statistics on primary education in Ghana: rates, ratios and indices

Appendix 5.2(a) Basic statistics on primary education in Ghana: rates, ratios and indices

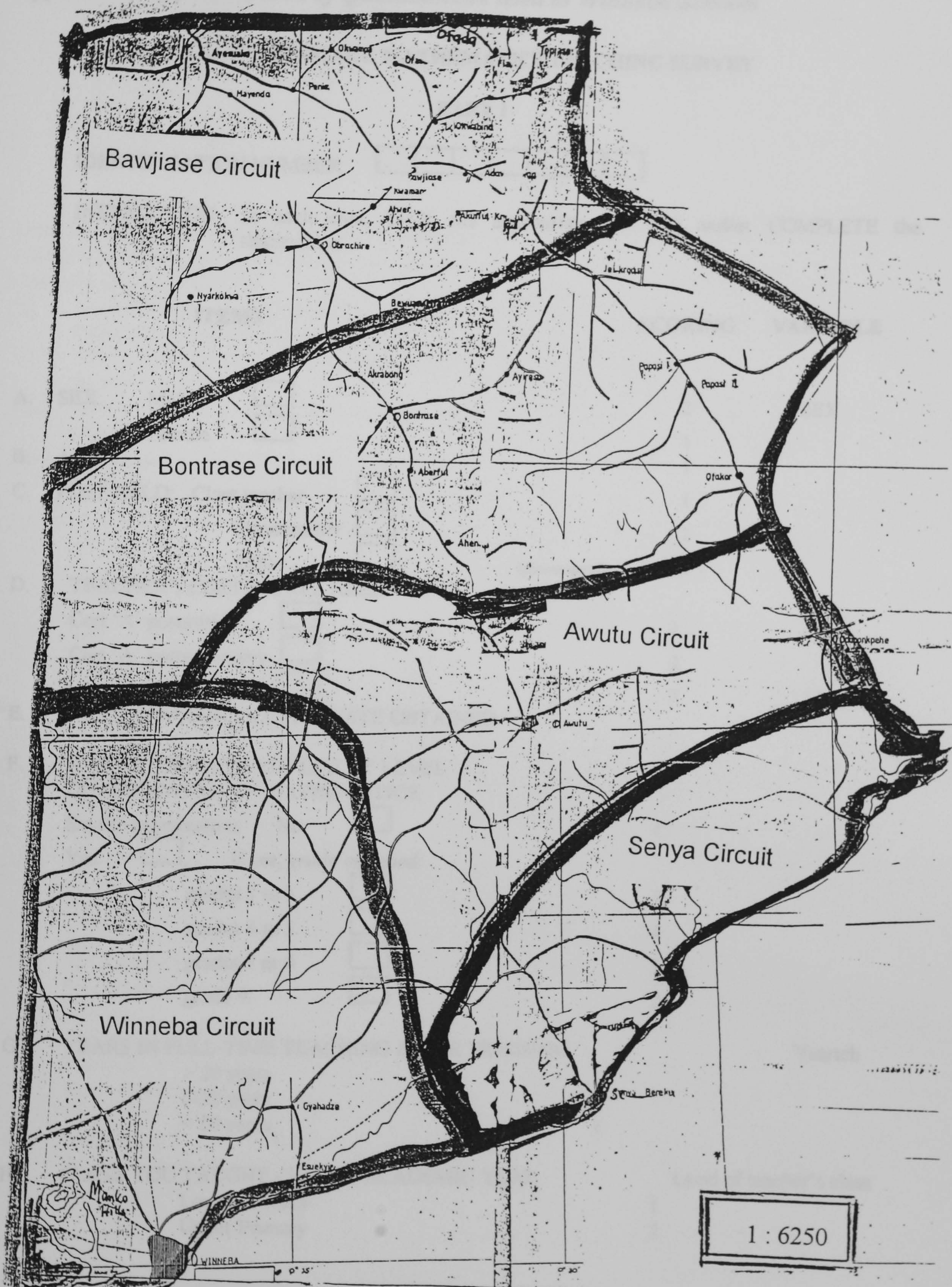
No. of Schools	9831	Total No. of Classrooms	49658	Average No of classrooms per school	5.05
Total No. of Classrooms in use	49658	Total No. of classes (stream)	61472	No. of Classes per classroom	1.24
Total No. of classes (stream)	61472	Total Enrolment	1703074	Average size of Class	27.20
Number of Schools	9831	Total Enrolment	1703074	Average size of School (enrolment)	173.24
Total No. of classes	61472	Total No. of Teachers	62859	Average No. of Teachers per class	1.02
Total No. of Teachers	62859	Total No. of Untrainted teachers	21146	% Wgo are Untrained	33.64
Total No. of Teachers	62859	Total Enrolment	1703074	No. of Pupils per Teacher	27.09

Appendix 5.2(b) Basic statistics on primary education in the Central Region of Ghana: rates, ratios and indices

No. of Schools	991	Total No. of Classrooms	5420	Average No of classrooms per school	5.47
Total No. of Classrooms in use	5420	Total No. of classes (stream)	6130	No. of Classes per classroom	1.13
Total No. of classes (stream)	6130	Total Enrolment	188388	Average size of Class	30.73
Number of Schools	991	Total Enrolment	188388	Average size of School (enrolment)	190.10
Total No. of classes	6130	Total No. of Teachers	6705	Average No. of Teachers per class	1.09
Total No. of Teachers	6705	Total No. of Untrainted teachers	1995	% Wgo are Untrained	29.75
Total No. of Teachers	6705	Total Enrolment	188388	No. of Pupils per Teacher	28.10

GMOEC- Ghana Ministry of Education and Culture- (1990)

Appendix 5. 3 Location of Educational Circuits of the Winneba District



Appendix 5. 4The Research Instruments

Appendix 5.4(a) Part I of Questionnaire used in Winneba Schools

GHANA PRIMARY MATHEMATICS TEACHING SURVEY

PART I

IDENTIFICATION NUMBER: ☐☐☐☐☐☐☐

INSTRUCTION: In each case, TICK the appropriate box (es) and/or COMPLETE the statement(s).

ITEMS		SCORING	VARIABLE
A.	SEX: Male ☐	2	SEX
	Female ☐	1	
B.	AGE:	1	
C.	POST HELD: Class teacher ☐	1	
	Headteacher ☐	2	
	Other ☐ (please specify ....)	3	
D.	TEACHER's CERTIFICATE HELD:		
	Cert 'A' postmiddle ☐	1	
	Cert 'A' postsecondary ☐	2	
	(please specify ...) other ☐	3	
E.	YEAR TEACHER's CERTIFICATE OBTAINED:		
F.	SCHOOL CERTIFICATE/GCE 'O' LEVEL QUALIFICATION IN MATHEMATICS:		
	Sat the examination: No ☐	1	
	Yes ☐, If yes, *grade obtained*:		
	grades 1 to 3 ☐	5	
	grades 4 to 5 ☐	4	
	grades 7 or 8 ☐	3	
	grade 9. ☐	2	
G.	YEARS IN FULL-TIME TEACHING AFTER TRAINING:		Yeartch
	> 20 years	1	
	6-20 years	2	
	< 20 years	3	
H.	CLASS YOU TAUGHT - 1992/93 ACADEMIC YEAR		Level of teacher's class
	Lower Primary	1	
	Upper Primary	2	

		SCORING	VARIABLE
I.	NUMBER OF PUPILS IN YOUR CLASS:		
	boys: .... girls:		Classize
	total: < 20	1	
	20-35	2	
	36-50	3	
	> 50	4	

1. COVERAGE IN PRIMARY MATHEMATICS TEACHING

Consider HOW MUCH TRAINING you have done on each of the following topics throughout the 1991/92 academic year and tick (√) :

(i) 'A GOOD DEAL OF TEACHING' If you taught the topic for more than 2 weeks;
(ii) 'SOME TEACHING' If you taught the topic for not more than 2 weeks;
(iii) 'NO TEACHING' If the topic was not taught at all; and
(iv) 'NOT INCLUDED' If the topic is not in the syllabus/textbook for your class.

		A Good Deal of Teaching	*Some Teaching*	*Virtually No Teaching*
1.	Sets	2	1	0
2.	Number and Numerals	2	1	0
3.	Measurement of Length	2	1	0
4.	Measurement of mass (or weight)	2	1	0
5.	Measurement of Area	2	1	0
6.	Measurement of capacity	2	1	0
7.	Measurement of volume	2	1	0
8.	Measurement of time	2	1	0
9.	Arithmetic Operations	2	1	0
10.	Plane geometric figures	2	1	0
11.	Solids and 3-D shapes	2	1	0
12.	The number plane and graphs	2	1	0
13.	Graphs - pictograms, bar and pie	2	1	0
14.	Measurement of angles	2	1	0
15.	Movement geometry	2	1	0
16.	Averages	2	1	0
17.	Integers	2	1	0
18.	Fraction	2	1	0
19.	Operation on fractions	2	1	0
20.	Rational	2	1	0
21.	Percentages	2	1	0
22.	Ratio and proportion	2	1	0
23.	Simple interest	2	1	0
24.	Money, profit and Loss	2	1	0
25.	Chance	2	1	0

2. Your three BEST primary mathematics topics.
WRITE DOWN 3 topics you ENJOY(ED) teaching most:
1st topic...
2nd topic...
3rd topic...

3. Your three WORST primary mathematics topics.
WRITE DOWN 3 topics you HATE(D) teaching most:
1st topic
2nd topic
3rd topic.

4. Supposing every primary teacher is to teach only his/her best subjects in the primary school, write down in order, THREE SUBJECTS THAT YOU WOULD MOST LIKE TO TEACH:
1st subject
2nd subject
3rd subject.

5. How many 30 MINUTES teaching-periods do you do each week in your present class (or the last class you taught) in teaching mathematics?

6. Circle a letter : A for ALWAYS
or U for USUALLY
or S for SOMETIMES
or N for NEVER

to show how often the teacher did the things described in each of the statements below in his/her mathematics teaching.

	SCORING				VARIABLE
	N	S	U	A	
1. Explain mathematics so that pupils can understand.	1	2	3	3	
2. Show enthusiasm in my teaching	1	2	3	3	
3. Allow pupils to explore different methods according methods according to their own ability	1	2	3	3	
4. Base the preparation of my weekly mathematics lesson notes on pupils' performance in the previous week.	1	2	3	3	
5. Use methods which do not encourage pupils to take part in class discussions	3	2	1	1	
6. Teach with ease and confidence any topic stated in my scheme of work	1	2	3	3	
7. Give exercises and mark pupils' work	1	2	3	3	
8. Teach for understanding and meaningful application of the subject rather than reproduction of materials	1	2	3	3	
9. Encourage pupils to find and (or use) their own methods in solving mathematics problems	1	2	3	3	
10. Encourage pupils to express their own ideas and to ask questions	1	2	3	3	
11. Get into difficulty when teaching topics in the primary mathematics syllabus	3	2	1	1	
12. Make valuable comments (and/or write them in pupils' workbooks) after marking their work	1	2	3	3	

13. Teach mathematics which is hard enough but not too hard for my pupils	1	2	3	3
14. Use humour to make my mathematics teaching interesting.	1	2	3	3
15. Plan each week's lesson strictly according to topics/ objectives stated in my scheme of work	3	2	1	1
16. Give meaningful answers to pupils' questions	1	2	3	3
17. Prepare and make us eof teqaching aids in my teaching.	1	2	3	3
18. Set tests/examinations which test what I teach.	1	2	3	3
19. Enable pupils to learn new topics and valuable things in mathematics.	1	2	3	3
20. Use approaches which make pupils to take greater interest in the subject	1	2	3	3
21. Engage pupils in practical activities (eg. shopping, measuring, constructing, etc.) when teaching mathematics	1	2	3	3
22. Use games and practical activities in teaching mathematics	1	2	3	3
23. Give homework which helps pupils to understand what they learn and make sure it is done	1	2	3	3
24. Criticise pupils' work, but do so constructively	1	2	3	3
25. Put much effort into my general/lesson-notes preparation	1	2	3	3
26. Make pupils feel unwelcome when they come to seek help/ advice during (or after) class	3	2	1	1
27. Use, mainly, methods and examples suggested in textbook and syllabus.	3	2	1	1
28. Make useful comments and meaningful remarks on pupils' progress in reports to parents	1	2	3	3
29. Ensure no pupils get left out of things	1	2	3	3
30. Encourage pupils to explore and use methods other than those suggested in the textbook and syllabus.	1	2	3	3
31. Hurt pupils' feelings or make them feel afraid	3	2	1	1
32. Identify pupils who are in difficulty (and/or worried) and help them to overcome what worries or bothers them.	1	2	3	3

7. In which order will you choose the following trained teachers for help when you are not certain about an aspect of mathematics you are expected to teach? (assume all are on the staff of the same school)

PUT THE ORDER (1st, 2nd, 3rd and 4th) IN THE BOX TO INDICATE how you will choose a teacher who has been teaching since his/her qualification for:

not more than 3 years	☐	1
4 to 10 years	☐	2
11 to 20 years	☐	3
over 20 years	☐	4

8. Finally, you are required to RATE primary teachers' "success in teaching mathematics" by considering HOW SUCCESSFUL, you think, THESE TEACHERS ARE IN DOING WHAT THEY ARE EXPECTED TO DO WHEN TEACHING MATHEMATICS.
How will you rate the mathematics teaching of the following.

	RATING OF MATHEMATICS TEACHING*			
	Highly successful	Successful	Slightly successful	Not successful
Yourself	4	3	2	1
Your Headteacher	4	3	2	1

* (Tick one box for yourself and one for your head)

Appendix 5.4(b) *Part II of Questionnaire used in Winneba Schools*

PART II

INSTRUCTION: In each case, TICK the appropriate box(es) and/or COMPLETE the statement(s)

EXPERIENCE OF INSERVICE ACTIVITIES IN MATHEMATICS

SCORING **VARIABLE**

1.1 Have you taken part in mathematics in-service activity/ activities (or in-service education programme(s) which involved activities in mathematics) since you began to teach after training?
no ☐ yes ☐

1.2 Have any of the mathematics in-service activities been organised solely for teachers on the staff of the school in which you teach?
no ☐ yes ☐
If YES, how many times? ....

1.3 How many of these mathematics in-service activities took place in the LAST FIVE YEARS? .
....

If YES, how many times?		Scoring
	none	1
	not more than three	2
	more than three	3

Please give details of the THREE most recent in-service activities (eg. courses, conferences, staff-training sessions, etc.) in which you have taken part in the LAST FIVE YEARS.

	Most recent activity A	Next activity preceding (A) B	Next activity preceding (B) C
Title or topic of in-service activity			
What YEAR was it organised?			
How long did it last? (eg. 5 full days or 3 x 2 hour sessions)			
TIME it took place: a) school time b) my own time c) split almost equally (Mark a, b or c as appropriate)			
Were you expected to do HOMEWORK? (yes/no)			

Appendix 5.4(c) Questionnaire used in Schools Outside Winneba

GHANA PRIMARY MATHEMATICS TEACHING SURVEY

PART I

IDENTIFICATION NUMBER: ☐☐☐☐☐☐☐

INSTRUCTION: In each case, TICK the appropriate box (es) and/or COMPLETE the statement(s).

ITEMS		SCORING	VARIABLE
A.	SEX: Male ☐	2	SEX
	Female ☐	1	
B.	AGE:	1	
C.	POST HELD: Class teacher ☐	1	
	Headteacher ☐	2	
	Other ☐ (please specify ....)	3	
D.	TEACHER's CERTIFICATE HELD:		
	Cert 'A' postmiddle ☐	1	
	Cert 'A' postsecondary ☐	2	
	(please specify ...) other ☐	3	
E.	YEAR TEACHER's CERTIFICATE OBTAINED:		
F.	SCHOOL CERTIFICATE/GCE 'O' LEVEL QUALIFICATION IN MATHEMATICS:		
	Sat the examination: No ☐	1	
	Yes ☐, If yes, *grade obtained*:		
	grades 1 to 3 ☐	5	
	grades 4 to 5 ☐	4	
	grades 7 or 8 ☐	3	
	grade 9. ☐	2	
G.	YEARS IN FULL-TIME TEACHING AFTER TRAINING:		Yeartch
	> 20 years	1	
	6-20 years	2	
	< 20 years	3	
H.	CLASS YOU TAUGHT - 1992/93 ACADEMIC YEAR		Level of teacher's class
	Lower Primary	1	
	Upper Primary	2	

SCORING VARIABLE

I. NUMBER OF PUPILS IN YOUR CLASS:

boys:	girls:		
total:	< 20	1	Classize
	20-35	2	
	36-50	3	
	> 50	4	

1. COVERAGE IN PRIMARY MATHEMATICS TEACHING

Consider HOW MUCH TRAINING you have done on each of the following topics throughout the 1991/92 academic year and tick (√) :

(i) 'A GOOD DEAL OF TEACHING' If you taught the topic for more than 2 weeks;
(ii) 'SOME TEACHING' If you taught the topic for not more than 2 weeks;
(iii) 'NO TEACHING' If the topic was not taught at all; and
(iv) 'NOT INCLUDED' If the topic is not in the syllabus/textbook for your class.

		A Good Deal of Teaching	*Some Teaching*	*Virtually No Teaching*
1.	Sets	2	1	0
2.	Number and Numerals	2	1	0
3.	Measurement of Length	2	1	0
4.	Measurement of mass (or weight)	2	1	0
5.	Measurement of Area	2	1	0
6.	Measurement of capacity	2	1	0
7.	Measurement of volume	2	1	0
8.	Measurement of time	2	1	0
9.	Arithmetic Operations	2	1	0
10.	Plane geometric figures	2	1	0
11.	Solids and 3-D shapes	2	1	0
12.	The number plane and graphs	2	1	0
13.	Graphs - pictograms, bar and pie	2	1	0
14.	Measurement of angles	2	1	0
15.	Movement geometry	2	1	0
16.	Averages	2	1	0
17.	Integers	2	1	0
18.	Fraction	2	1	0
19.	Operation on fractions	2	1	0
20.	Rational	2	1	0
21.	Percentages	2	1	0
22.	Ratio and proportion	2	1	0
23.	Simple interest	2	1	0
24.	Money, profit and Loss	2	1	0
25.	Chance	2	1	0

2. RATING SUCCESS IN MATHEMATICS TEACHING
HOW SUCCESSFUL, you think, THESE TEACHERS
In the teaching of primary mathemtics RATE HOW SUCCESSFUL.
(i) you are?
(ii) you think your headteacher is?

	RATING OF MATHEMATICS TEACHING*			
	Highly successful	Successful	Slightly successful	Not successful
Yourself	4	3	2	1
Your Headteacher	4	3	2	1

* (Tick one box for yourself and one for your head)

PART II

PARTICIPATION IN IN-SERVICE ACTIVITIES

IDENTIFICATION NUMBER: ☐☐☐☐☐☐☐☐☐

A. In-service Education Courses co-ordinated from the Ministry of Education in the last 5 years.

Courses and Dates	Tick if you attended
1. Courses for training of Teachers for JSS, May/June 1987	
2. Orientation course for primary school Heads; August/September 1987	
3. In-Service Training Course for Teachers of Science in JSS: January 1990	
4. In-service course on continuous Assessment for Primary School teachers - August/September 1991	
5. In-Service course on teaching of Reading skills for Primary 1 & 6 teachers; September/October 1991	
6. In-Service course on teaching of Reading skills for Primary 6 teachers; July 1991	

7. In-Service course on teaching life-skills for lower primary teachers; May 1992

8. In-service course on teaching English for Primary 4 teachers; October 1992

Total number of courses attended ....

none	1
not more than three	2
more than three	3

B. Mathematical Association of Ghana (MAG) Workshops/Conferences

Have you ever attended a workshop or conference organised by the Mathematical Association of Ghana?

No ☐

Yes ☐ If yes, complete the table:

Year you attended	Town (where it was held)	Organisers (tick (√) one)		
		District Branch	Regional Branch	National Executive

C. Prescribe/Promotion Courses:

Indicate by a tick (√) in the appropriate box, if you have attended any prescribe and/or promotion courses.

	Assistant Superintendent		Superintendent	
Year	Prescribe Course	Promotion Course	Prescribe Course	Promotion Course
1987				
1988				
1989				
1990				

1991
1992

Appendix 5.4(d) Scheme for Curriculum analysis and content analysis

PART I

CURRICULUM ANALYSIS SCHEME

Cross-cultural curriculum adaptation concerns considered in the curriculum analysis

1. Are the aims of the curriculum consistent with the overall goals of primary education in Ghana?

2. Is the content of the curriculum balanced with respect to the needs of pupils expressed by the overall goals of primary education in Ghana?

3. Is the language of the pupils' text (length and complexity of sentence, use of foreign words and mathematical terminology, etc.) suitable for the majority of pupils?

4. Does the level of complexity of the content asked for in the curriculum materials, fit the ability of the majority of pupils?

5. Is there a match between teachers and pupils' expectations and the roles ascribed to them by the teaching and learning activities in the curriculum materials

6. Does the structure of content presented in the official curriculum reflect current thinking about the nature of school mathematics ?

7. Do the roles ascribed to teachers and pupils by the teaching and learning activities in the curriculum match the roles reflected by views on what is currently valued globally in school mathematics?

PART II

The Schedule for content analysis of the Official Curriculum

1. What is the number of pages covered by topics in the official textbooks?
2. What is the number of objectives stated on topics presented in the official syllabus?
3. What is the number of mathematical kernels that are related to each topic presented in the official syllabus?
4. What is the number of words in the official syllabus associated with the following forms of mathematics learning tasks: applications, concepts and skills.
5. What is the number of exercises set in the official textbooks on concepts, skills and applications exercises?
6. What proportions of instructions in the teacher's handbooks are likely to bring about the following forms of classroom organisation:- whole-class, individual and small-groups teaching?
7. What forms of classroom exchanges - eliciting, informing, directing, and checking - are emphasised by the teaching activities presented in the teacher's handbooks?

Appendix 5. 5Names and schedules of officials of the GES district office at Winneba interviewed

NAME OF OFFICER	RANK/ SCHEDULE
Mr. Stephen Baidoo	Director - Head of GES Winneba District Office
Mr. Paul Ekpale	Superintendent -The District Subject Organiser in charge of mathematics at the GES Winneba District Office
Mr. Nkabi, K.	Assistant Director - Officer in charge of in-service and training at the GES Winneba District Office
Mr. Ocloo, M.	Principal Superintendent - Officer in charge of the Bontrase Circuit
Mr. Morris-Mensah, K.	Principal Superintendent - Head teacher of Winneba ATTC Demonstration Primary School.
Mrs. Agnes Appeadu	Senior Superintendent - Head teacher of Winneba ATTC Demonstration Primary School.
Mr. Ammisah, S.E.	Deputy Director General, GES Headquarters, Accra.
Mr. Hammond, R.	Assistant Director - Officer in charge of in-service and training at the GES Headquarters, Accra
Mr. Konadu, D. A.	Director - Budget and Planning, GES Headquarters, Accra
Mrs. Sarah Oppong	Director - Basic Education, GES Headquarters, Accra
Mrs. Eleanor Ohene	Officer in charge of teachers' professional development, GNAT Headquarters, Accra
Mr. Kofi Nyiaye	Officer in charge of teachers' professional development, GNAT Headquarters, Accra
Mr. Mante,	Principal Superintendent - Teacher Education Division, GES-Headquarters, Accra

Appendix 5.6 Factor* analysis of teachers' frequency of using teaching skills.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Sending meaningful reports to parents on pupils' performance	**.68437**	.37922			.32772
Using approaches that bring conceptual	**.62270**		.39247		
Encoraging the use of pupils' own method	**.59577**				
Criticising, constructively, pupils' work	**.56996**	.30565		.39181	
Making valuable comments after marking pupils' work	**.56428**		.38784		
Ensuring all pupils are involved in lesson	**-.51054**				
Identifying and helping pupils in need of special attention	**.50392**				
Basing preparation of weekly lesson notes on pupils' previous performance	**-.45911**			.42819	
Teaching with confidence topics presented in lessons	**.44519**				-.30785
Putting a good deal of effort into pre-lesson preparation	**.44510**			.38451	-.34996
Using mainly textbook examples and exercises	-.36283	**.67100**			.33620
Using methods which discourage discussions in lessons		**.61041**			
Explaining mathematics so that pupil's can understand		**-.57410**			
Showing enthusiasm in mathematics teaching	-.43755	**-.48483**			
Using humour to make mathematics lessons interesting	-.37061	**-.43765**	.35711	.30330	
Teaching challenging mathematics from only textbook sources	.33293		**-.59921**		
Using mainly formal assessment techniques			**.51513**		
Geting into difficulty while teaching mathematics	.32098	.32384	**-.48094**		.39594
Making pupils afraid when teaching mathematics	-.35016		**.44482**		
Giving meaningful answers to pupils' questions		.53745		**.56326**	
Preparing and using teaching/learning material in lessons			.41284	**.54711**	
Seting and marking of homework					**.68953**
Engaging pupils in practical and game activities in lessons		-.41198	.33861	.44819	**.45569**

[*Loadings not less than 0.3]

Appendix 5.8 Extracts of the tape-recorded lesson transcripts

Explanations of the conventions used in the lesson transcripts

T → teacher

Px (where x is a letter) →a pupil with the initial xy who was called by name by the teacher

Pn (where n is a number) → a pupil called by the teacher but not by his/her name.

Ps → several pupils speaking simultaneously

C → class (or a large number of pupils) making a response

C_{rl} → class making a real response; ie. requiring thought and decision

C_{ec} → class making an echo response that is, repeating a phrase or word supplied by teacher, or from a pupil's response

C_{rt} → class making a routine response, that is, responding to non-genuine checks of understanding or providing a verbal or non-verbal response to teacher's statement

Pn → Pupil n (where n is a number) called by the teacher but not by his/her name making a real response.

P_{XY}*→ Pupil called XY is asked to make an echo response.

P_{XY} → Pupil called XY is asked to make a routine response.

Wording in brackets thus ( ) indicates actions or other commentary on the progress of the lesson.

/////////// indicates spoken language which was not clearly audible from the type.

.... indicates silence from pupil(s) in response to an initiation from the teacher.

.. indicates part of the lesson omitted in the transcription.

T_e → teacher eliciting exchange

T_d → teacher directing exchange

T_i → teacher informing exchange

T_c → teacher checking exchange

LESSON 1

School : Anglican Primary, Winneba. **Class:** P.6. **Class-size:** **Duration of lesson:** 30 mins.
Lesson topic: Multiplication of fractions (*The tape started five minutes after the lesson had begun*).

Exchange No./Type		Initiation move	Response move	Feedback move
		(The figure had been drawn on the chalkboard. The teacher had told the pupils the plane sheet of paper he was holding could be folded to get the parts shaded on the board. The lesson continued...		
1.	T_e	T : Eh? Is a fraction, except what?	Ps : /////////	
2.	T_e	T : So when you have a whole number, a paper like		

		this (raising the sheet in his hands), is what? A whole number. And therefore it can be divided into how many parts?	C :	
3.	T_e	T : Eh? It can be divided into how many parts? Eh? Eh? Eh?	P_1 : four P_2 : three P_3 : different parts P_5 : /////	T : If you know raise your hand.
4.	T_e	T : It can be ..... Yes?	P_2 : four parts P_4 : three parts P_1 : five P_5 : one	T : Ehe, who else, ... Yes? T : Three. Ehe, yes? T : ehe? P5 : ////// T : The thing is one whole part. If one part is what we require, do we have to divide again?
			P_6 : ten P_7 : thirteen P_8 : eighteen	T : Yes T : Mhm T : Yes
5.	T_e	T : O.K. so it can be divided into so many parts because it is one, eh? .... Because it is one it can be divided into how many parts?	C : ////// Cec: So many parts	
6.	T_e	T : O.K. now, this has been divided ... (pointing to the figure on the board, then showing the class the sheet in his hand,		

		he continued). We've taken this one to be one paper. It has been divided into how many parts on the board?	C_{rl}: Three parts	T : O.K.
7.	T_d	T : Now watch over, we are going to divide it again (Teacher inserts four vertical lines into the shape on the board)	C : //////	
8.	T_e	T : O.K. How many parts have I divided it into?	P_s : ////// (murmurings from efforts to count the parts) ... fifteen C_{rl} : Yes	T : fifteen?
9.	T_e	T : O.K. The first parts, I divided them into how many parts?	C_{rl} : Three	
10.	T_e	T : So we have ... one, ... O.K. let's see (he pointed to, and counted, rows) 1, 2 and then 3. So when we come to this side (pointing to the parts in columns) how many parts are there?	C_{rl} : Five	T : Five
11.	T_e	T : O.K., we have .... (teacher begins to count) 1, 2, 3, 4, and 5	C : /////// (pupils trying to count along with ....teacher).	
12.	T_d	T : I want someone to shade a portion of 'two-over-three' .... Ofess?	P_{of} : (Ofes shaded two rows out of three in ....the figure on the board).	T : Fine, O.K. ..... ////////

13.	T_e	T : Now we want to find what we shall get when we multiply two-over-three by four-over-five (he writes the expression on the board). First four-over-five, four over what?	C_{ec} : Five carefully.	T : O.K. watch
14.	T_d	T : (Teacher draws a new rectangle on board) O.K. now, we want someone to shade four-over-five .... Yes?	P_4 : (shaded four columns out of five in the figure on the board).	
15.	T_c	T : Is he right?	C_{rl} : Yes	
16.	T_e	T : O.K. Who can tell me .... why as four, is a whole part eh; and five cannot divide the four and five must be divided into five parts; and this five equal parts four must be shaded out of that eh! okay; so how would you term it? How would you write that 4, Mm? ..... Yes Ehe?	P_3 : four-over-fifteen P_8 : five-over-four P_4 : four-over-five five	T : four-over-fifteen, okay, that is your observation. T : YEs, is four-over
17.	T_e	T : So what it means .... What is the meaning ? What does it mean?	P_0 : /////// we have five portions, we have five portions and we have shaded four, so it has left one.	T : Right, Good
18.	T_i	T : So it means that out of the five parts that are being divided four have been shaded out of what ...		

		the five ...... So it is what ..... four-over-five.	C_{rl} : four-over-five	
19.	T_d	T : I want someone to use the chalk to shade another position, two out of the three we divided it, ... two out of the three? (Teacher gives chalk to pupil)	P_9 : (Drew a rectangle on board and shaded two rows out of three) C_{rt}: (pupils clapped the praise rhythm - taa taa ta ta taa)	T : Good, clap for her .... You see this time Florence she is trying to challenge you.
20.	T_d	T : O.K. someone also should come and write the figure that has been shaded ... (hands over chalk to a pupil)	P_{10}: (pupil writes 2/3 on board)	
21.	T_c	T : Is he right?	C_{rl}: Yes C_{rt}: (pupils clapped the praise rhythm)	T : Okay, give her a hand.
22.	T_e	T : Hei, Akos, tell us the meaning of this? Tell us the meaning of this.	P_{ak}: /////// Because we have 3,... we divide 4 ...///// P_{ed}: We divided the portion into three parts and we shaded two of the parts.	T: The explanation is not coming properly ... Eh..m Edem, help her. T : Good
23.	T_i	T : We divided the paper into 3 equal parts and	C_{ec} : three ...	

		then two parts have been shaded out of what? The three equal parts .... eh. So it is what? ... two-over-three	C_{ec} : two-over-three	
24.	T_e	T : Now we are going to multiply this two-over-three by ... (teacher writes expression on board) two-over-three times four-over-five .. Watch carefully (pointing to the figure with 3 by 5 squares on the board) ... When we count the whole portion we have to get a certain number. Let's see if we can get that number.	C //////	
25.	T_d	T : Let us all count	C_{rt} : 1, 2, 3, ... 15	
		T : So, we have 15 eh?	C_{rl} : Yes	T : Okay
26.	T_i	T : Now, the whole thing is, you'll see that ... this is four-over-five and two-over-three, we are going to multiply, and this is the way we have to do it: First you'll take the numerators and multiply the two numerators. That is, multiply them. That is, 4 by 2 and we shall get what?	C_{rl} : Eight	T : OK.
27.	T_e	T : So let's count the portions where it has been shaded, to see whether we can get eight. Who can do that for us? ... Yes Edem go and do it for us, count the shaded portions	P_{ed} : 1, 2, 3, ... 8 P_{ed} : eight	T : Is what? T : O.K.
28.	T_e	T : You see that this is the part you shaded and it is 2 parts out of the 3. And here too, where it is being divided into five, four shaded out of that; so we multiplied the two parts horizontally with what ... vertical. So this is the two, the	C : /////	

			numerators; 2 and 4.		
29.	T_e	T :	And 2 and 4 will give us what?	C_{rl} : 8	
30.	T_e	T :	So, 2 multiplied by 4 is equal to ...?	C_{rl} : Eight	
31.	T_e	T :	And then we are to multiply the denominators 3 and 5, eh. Now, when we counted the whole thing, we had what?	C_{rl} : Fifteen	
32.	T_e	T :	So this means that 3 multiplied by 5 will give you what?	C_{rl} : Fifteen	
33.	T_e	T :	(Teacher completes the multiplication sentence on the board) ... So we see that, two-over-three multiplied by four-over-five will guve us what?..	Ps : ////// Eight ... over //// eight?	T : will give us only
			Will give	C_{rl} : Eight-over-fifteen	
34.	T_e	T :	Do you see?	C_{rt} Yes	T : OK.
35.	T_e	T :	Now, if we want to multiply three-over-four by five-over-two (teacher wrote expression on the board), if we multiply the two fractions, what will they give us? .... Yes?	P11 : Six-over-twenty Edem	T : Is he right? ...
				P_{ed} : Yes for him.	T : O.K. Good, clap
				C_{rt} : (pupils clapped the praise rhythm)	
36	T_d	T :	Open your textbooks at page 45. Copy and do the	Ps : (Pupils fetch for their	

exercises, from No. 4 to 9.		exercise books, opened textbooks and began exercise).

[When the researcher went round ten minutes after the pupils have began with their class works, only five out of the 38 had been able to complete three of the products correctly. Majority of the pupils had not been able to complete one]

Lesson 2.

School: A.T.T.C. Demonstration, Winneba. Class: P1. Class size: Duration of lesson: 30 min. Lesson Topic: Addition - Union of Sets.

Exchange No.	Type		Initiation move		Response move		Feedback move
1.			(Teacher gets two groups of pupils, with members two and three respectively, to stand in front of class)				
	T_e	T :	Look at these sets. How many members are in each of these sets. How many in this one?	Ps : P_1 :	/////// two, three two	T : T :	Ehe, You? Yes
2.	T_e	T :	How many members in this one?	P_2 :	three	T :	Yes.
3.	T_i	T :	Now watch, we are going to bring together the sets. (The teacher moved toward the two groups in front. She called to the groups to come to her). You see, you see , ... They have come together. I did something before they came together (raising her both hands up and dropping them slowly in a horse-shoe formation, ... writing the 'U' symbol on the board). It is this sign. It is this sign. It is called 'Union'. If you want to bring something together, you will				

			do this (forming the 'U' shape with both hands), so you see, we use the union sign. You see?	C_{rt} :	Yes madam.		
4.	T_e		(Teacher asked two groups standing in front to take their seats. She draws two sets with a 'U' sign between them on board).				
		T :	How many members are in this set? (pointing to the set on the left) .... Yes Botse?	Pa :	three	T :	Good
5.	T_e	T :	How many members are in the other set? ... You .... eh, Joyce.	Pj :	two	T :	Fine
6.	T_e		(Teacher wrote an equal sign to the right of the sets on the board and drew a large loop after it). If we have a third set, (pointing to the loop), a big set, and bringing together the two small sets, how many members shall we have in the big set?..	C :	/////		
7.	T_e	T :	Who can come and draw the members in the big set? Yes ... Ato	Pa :	(Ato copied members into the loop on the board)	T :	Is he right?
				Ps :	Yes	T :	Well done, Ato.
8.	T_d		(Teacher asks pupils to get their counters (bottle tops))				
		T :	Make two sets, put them together and find the union. (Teacher moved round columns of pupils to ensure they are working).		(Pupils got their bottle tops to do activity.		

9.	T_d	T : I want some people to go to the board and draw the set they made ... yes. Esi, Ofori, Ghartey and Sam	Ps : (Draw sets on board as others look on).	
10.	T_e	T : Watch all of you (pointing to Esi's work). How members are in her first set?	P_3 : four	T : Yes
11.	T_e	T : How many members are in her second set?	P_4 : three	T : Yes.
12.	Te	T : How many members has she got altogether in the two sets?	P_5: Six Pj : No	T : Is she right?
13.	T_d	T : Let's all count it.	C_{rt} : One, two, ... seven	
14.	T_e	T : So, it is what?	C_{rl} seven	

(The sets drawn by the other three pupils on the boards were discussed in a similar manner. The lesson ended shortly afterwards).

Lesson 3.

School : S.T.C. Demonstration Primary. Class: P3. Class-size Duration: 30 mins. Lesson Topic: Geometry

Exchange No./Type		Initiation move	Response move	Feedback move
		(Before the commencement of the lesson, the teacher has drawn the four basic shapes on the board		
1.	T_d	T : Class stand ...... sit ..... stand	C : (pupils stand up, sit down and stand up again behind their	

			tables).	
2.	T_i	T : We learnt about these shapes last week (pointing to the illustration on the board). Let us all say their names once more C :	//////////	
3.	T_e	T : 'Triangle' .... (pointing to the illustration on the board) .... all of you ..... C_{eh} :	Triangle	
4.	T_e	Triangle ...	C_{eh} : Triangle	
5.	T_e	T : 'Rectangle' ... all of you	C_{eh} : Rectangle	
6.	T_e	T : ...Again....	C_{eh} : Rectangle	
7.	T_e	T : Now, ... square ..	C_{eh} : Square	
8.	T_e	T : Ehe, ...	C_{eh} : Square	
9.	T_e	T : The last one, 'circle' .... all of you ...	C_{eh} : Circle	
10.	T_e	T : Again, 'circle'	C_{eh} : Circle	T : OK. good.
11.	T_e	T : Now, who can point at a square on the board)... ... Yes Kuukua? (handing her pointer over to Kuukua)	Pk : This is a square (pointing to a cirlce)	T : No
12.	T_c	T : Is this a square?	C_{rl} : No	
13.	T_i	T : Sit down (referring to Kuukua after taking the pointer from her). Square, show us the square ... Yes ... Botse	Pb : This is the square C_{rt} : (Pupils clapped the praise rhythm - taa taa ta ta ta taa)	T : OK. clap for him.

14.	T_e	T : Alright, who can show us the triangle .. Hammond? for her.	Ph : This is the rectangle.	T : Very good, Clap
			Crt : (pupils clapped the praise rhythm).	
		(Teacher took pupils out of the classroom to look at shapes. Their first stop was near a wash basin which stood on a wooden stand in the middle of the long verandar).		
15.	T_e	T : What shape do you see at the top of this basin?	C_{rl} : Circle.	
16.	T_e	T : What else has a cirlce shape around here?	Ps : Yes teacher, yes.	
17.	T_e	T : Yes ... Amuzu	Pa : The stones arranged round the flag post.	T : Good
18.	T_e	T : Who can name another thing? ... Yes Ocran him.	Po : The tyres of Mr Ekpale's motorbike.	T : Yes Good, clap for
			Crt : (pupils clapped the praise rhythm).	
19.	T_e	T : Any other thing?	Ps : Ye..s, yes teacher, /////// (pupils becoming noisy)	
10.	T_e	T : O.k, o.k tell us, Henifer Pj :	The water tank (pointing to the water reservoir	T : Right

					of a bungalow near the school)		

(The lesson continued in the above manner till all other three shapes have been identified in objects around the school. Pupils were returned to the classroom, and then made to identify also objects with the shapes that can be found in the classroom).

21.	T_i		(Teacher picks up a textbook and holds it up to the class)				
		T :	This is an edge (moving her finger along the edges of the book). It is an edge because we can feel it (she writes "edge" on the board).	C :	....		
22.	T_e	T :	All of you say 'edge'	C_{eh} :	Edge		
23.	T_e	T :	Again	C_{eh} :	Edge		
24.	T_e	T :	When we put the book on the paper and trace round it, or draw a line around it), what shape shall we get?	C_{rl} :	rectangle	T :	Good
25.	Ti	T :	(Teacher traced book on board) Because we cannot feel the line in this shape (referring to the traced outline) we call the lines 'sides of the shape'. So, as you can see, a rectangle has four sides (pointing to the board - she goes to the board to write - 4 sides).				
25.	T_e	T :	All of you say 'a rectangle has 4 sides'	C_{ec} :	A rectangle has four sides.		

27.	T_e	T : Let us all count the sides ... one, two, three, four.	C_{rt} : One, two, three, four	
28.	T_e	T : How many sides has a square? ... Yes Wilson.	Pw : Four	T : Is he right?
			C_{rl} : Yes	
29. if you	T_e	T : How many sides has a triangle?	Ps : /////	T: Put up your hands know the answer.
30.	T_e	T : Ye...s .... ruben ... (Teacher wrote the following exercise on the board): Copy and complete these: This shape is a .... It has .... sides. This shape is a .... It has .... sides.	Pr : Three	T : O.K.
31.	Td	T : Copy the shape and the sentences and complete the sentences.	Ps : (Pupils got their books and began with the exercise).	

Appendix 6. 1 Coverage of content presented in the five topic categories

Table 6. 1(a) Estimates of coverage of content presented in the five topic categories

Topic	Number of kernels counted in syllabus	Number of objectives counted in syllabus	Number of pages covered in textbooks	Number of exercises* set in textbooks
Basic number and fractional concepts	336 (20.1%)	76 (24.6%)	143 (20.1%)	1453 (20.7%)
Commercial arithmetic and data handling	116 (6.9%)	34 (11%)	38 (5.3%)	281 (4.0%)
Geometric concepts	350 (20.9%)	46 (14.9%)	89 (12.5%)	782 (11.1%)
Measurement concepts	168 (8.5%)	24 (7.7%)	35 (4.9%)	392 (7.4%)
Number operations	726 (43.4%)	129 (41.7)	405 (57.0%)	3984 (56.8%)

Appendix 6.1(b) Coverage of the official curriculum by textbook exercises on concept development, computational skills and applications

Category of topics	Number of concept development exercises	Number of skill development exercises	Number of application exercises
Basic number and fractional concepts	591 (26.6%)	778 (18.7%)	84 (13.1%)
Commercial arithmetic and data handling	160 (7.2%)	95 (2.3%)	26 (4.1%)
Geometric concepts	583 (26.2%)	184 (4.4%)	15 (2.3%)
Measurement concepts	342 (15.4%)	160 (3.8%)	16 (2.5%)
Number operations	549 (26.7%)	2939 (70.7%)	496 (77.9%)

Appendix 6. 2 Teachers' choice of topics they 'enjoyed' and 'hated' teaching

Appendix 6. 2(a) Teachers' choice of topics they 'enjoyed' and 'hated' teaching

TOPICS	Proportion of teachers 'enjoying' teaching	Proportion of teachers 'hating' teaching
Averages - mean, median, mode	8.70	1.23
Chance (or probability)	.00	.00
Graphs and tabular data	4.35	2.47
Movement (or transformation) geometry	1.09	12.35
Descriptive geometry- points, lines, 2&3-D figs	1.09	6.17
Angles - measurements and applications	.00	.00
Descriptive geometry- points, lines and 2-D figs	3.26	11.11
Measurement and applications	1.08	5.31
Sets and numbers	27.17	1.23
Fraction	10.87	1.23
Numbers and numerals	11.96	4.94
Algebra and numbers (number sentences,	1.09	7.41
Rational numbers	.00	3.70
Integers and the four basic operations	2.17	.00
Fractions and the four arithmetic operat	1.09	.00
Whole numbers and the four arithmetic operations	14.13	8.64

Appendix 6.2(b) Teachers' choice of topics they 'enjoyed' and 'hated' teaching by topic categories

Topic categories	Proportion of teachers 'enjoying' 'teaching	Proportion of teachers 'hating' teaching
Basic number and fractional concepts	50.00	7.41
Commercial arithmetic and data handling	18.48	20.99
Geometric concepts	6.52	37.04
Measurement concepts	7.61	22.22
Number operations	16.30	12.35

Appendix 6. 3 Mean content coverage ratings for topics presented in teachers' actual classroom teaching in the 1991 to 1992 school year

Code	TOPIC	Mean	Standard Deviation	Number of valid cases
1.10	Averages - mean, median, mode	1.16	.83	74
1.20	Chance (or probability)	0.30	.60	43
1.30	Graphs and tabular data	0.91	.86	82
2.10	Movement (or transformation) geometry	0.65	.80	65
2.20	Descriptive geometry (points, lines, 2-	0.78	.75	87
2.30	Angles - measurements and applications	1.09	.76	75
2.40	Descriptive geometry (points, lines and	1.34	.68	103
3.10	Measurement and applications	0.98	.65	127
4.10	Sets and numbers	1.86	.41	134
4.20	Fraction	1.63	.57	92
4.30	Numbers and numerals	1.87	.36	123
5.10	Algebra and numbers (number sentences,	0.98	.85	87
5.20	Rational numbers	1.32	.73	84
5.30	Integers and the four basic operations	1.62	.69	86
5.40	Fractions and the four arithmetic operat	1.42	.69	79
5.50	Whole numbers and the four arithmetic operations	1.49	.53	134

Appendix 6. 4Ratings of coverage in teachers' instruction (*I*), and of the official curriculum (*O*)

Appendix 6.4(a) Ratings of coverage in teachers' instruction (I), and of the official curriculum (O)*

TOPICS	Rating of coverage by textbook exercises	Rating of coverage by textbook pages	Rating of coverage by syllabus objectives	Rating of Teachers' mean content coverage
Averages - mean, median, mode	1.00	1.00	1.00	2.00
Chance (or probability)	1.00	1.00	1.00	1.00
Graphs and tabular data	1.00	1.00	1.00	2.00
Movement (or transformation) geometry	2.00	1.00	1.00	2.00
Descriptive geometry- points, lines, 2&3-D figures	2.00	1.00	1.00	2.00
Angles - measurements and applications	2.00	1.00	1.00	2.00
Descriptive geometry- points, lines and 2-D figures	2.00	2.00	3.00	2.00
Measurement and applications	2.00	2.00	2.00	2.00
Sets and numbers	2.00	3.00	3.00	3.00
Fraction	2.00	2.00	2.00	3.00
Numbers and numerals	3.00	3.00	3.00	3.00
Algebra and numbers (number sentences,	2.00	2.00	1.00	2.00
Rational numbers	2.00	2.00	1.00	3.00
Integers and the four basic operations	2.00	2.00	2.00	2.00
Fractions and the four arithmetic operat	3.00	3.00	3.00	2.00
Whole numbers and the four arithmetic operations	3.00	3.00	3.00	2.00

*Criteria for rating coverage in the official curriculum (*O*) and in teachers' instruction (*I*)

	Not covered 0	Mentioned 1	Covered 2	Emphasised 3
Textbook pages covered by topic	0 pages	1 - 10 pages	11 - 40 pages	pages > 40
Number of objectives stated in syllabus on topic	0 exercises	1 - 10 exercises	11 - 20 exercises	exercises > 20
Teachers' mean rating of coverage	teachers' mean coverage rating 0	teachers' mean coverage rating < 0.49	teachers' mean coverage rating 0.50 to 1.49	teachers' mean coverage rating ≥ 1.50

Appendix 6.4(b) Ranks of estimates of coverage of the official curriculum (O) and in teachers' instruction (I)

TOPICS	Ranks of ratings of coverage by textbook pages	Ranks of ratings of coverage by syllabus objectives	Ranks of ratings of Teachers' mean content coverage
Averages - mean, median, mode	3.5	4.5	8.0
Chance (or probability)	3.5	4.5	1.0
Graphs and tabular data	3.5	4.5	4.0
Movement (or transformation) geometry	3.5	4.5	2.0
Descriptive geometry- points, lines, 2&3-D figures	3.5	4.5	3.0
Angles - measurements and applications	3.5	4.5	7.0
Descriptive geometry- points, lines and 2-D figures	9.5	14.0	10.0
Measurement and applications	9.5	10.0	5.5
Sets and numbers	14.5	14.0	15.0
Fraction	9.5	10.0	14.0
Numbers and numerals	14.5	14.0	16.0
Algebra and numbers (number sentences,	9.5	4.5	5.5
Rational numbers	9.5	4.5	9.0
Integers and the four basic operations	9.5	10.0	13.0
Fractions and the four arithmetic operat	14.5	14.0	11.0
Whole numbers and the four arithmetic operations	14.5	14.0	12.0

Appendix 6.4(c) Ranks of estimates of O and I, and ranks of differences between the related pairs

Topic Code	Rating of O_1 A	Rating of O_2 B	Rating of I C	$I-O_1$ D	Ranks of $\lvert I-O_1\rvert$ (N=14) E	$I-O_2$ F	Ranks of $\lvert I-O_2\rvert$ (N=15) G
1.10	1.00	1.00	2.00	1.00	5.00	1.00	5.50
1.20	1.00	1.00	1.00	.	.	.	.
1.30	1.00	1.00	2.00	1.00	5.00	1.00	5.50
2.10	1.00	1.00	2.00	1.00	5.00	1.00	5.50
2.20	1.00	1.00	2.00	1.00	5.00	1.00	5.50
2.30	1.00	1.00	2.00	1.00	5.00	1.00	5.50
2.40	2.00	3.00	2.00	.	.	-1.00	**5.50**
3.10	2.00	2.00	2.00	.	.	.	.
4.10	3.00	3.00	3.00	.	.	.	.
4.20	2.00	2.00	3.00	1.00	5.00	1.00	5.50
4.30	3.00	3.00	3.00	.	.	.	.
5.10	2.00	1.00	2.00	.	.	1.00	5.50
5.20	2.00	1.00	3.00	1.00	5.00	2.00	11.00
5.30	2.00	2.00	2.00	.	.	.	.
5.40	3.00	3.00	2.00	-1.00	**5.00**	-1.00	**5.50**
5.50	3.00	3.00	2.00	-1.00	**5.00**	-1.00	**5.50**
				N = 9		**N** = 11	
					T = 10		***T*** =

16.5

The procedure used in calculating the statistic T

The differences between the pairs of ratings (in columns C & A, and C & B) were calculated, always subtracting in the same direction (i.e. I_i - O_i). Differences equal to zero were eliminated, and the number of pairs, N, reduced accordingly. The differences were then ranked. In the ranking, the *absolute values* of the differences were used, assigning a 1 to the smallest, a 2 to the second smallest, and so forth. Where two or more absolute differences tied for the same rank, the average of the ranks that would have been assigned to these differences was assigned to each member of the tied group. Then the ranks associated with the least occurring sign were added. This sum is referred to as the T statistic. As the least frequent sign in columns E and G (in Appendix 6.4b) were both negative, the negative ranks, which have been highlighted in these columns, were added. The T-statistics obtained for the differences between the pairs of ratings in columns C & A and C & B were 10 and 16.5 respectively.

The probability that T is less than or equal to some value, T_o, has been calculated for a combination of sample sizes and values of T_o (Wilcoxon, 1949). These probabilities, usually presented in a Table, can be used to find the rejection region for the test based on T. That is, the T values serve as critical values or the maximum values that T can take to be within a particular significance level. In a two-tailed test for the null hypothesis, i.e. $H_o \rightarrow I = O$, one cannot reject H_o at 0.05 level unless the T-statistic obtained is equal to or less than the predetermined critical value of T for the relevant number of non-zero differences from which the unless the T-statistic was calculated. That is, the hypothesis can only be rejected if T does not exceed all critical values in the probability table.

In the case of the first of the two T values calculated above (ie T_1 = 10), since N_1, (that is, the relevant number of non-zero differences from which T_1 was calculated) was 9, the lowest critical value read in the Wilcoxon Table, which T should not exceed for significance at 5% level, was 6. The T_1 value of 10 obtained certainly exceeds this relevant critical value, and therefore not significant. Similarly, the second T value (T_2 = 11) was obtained with an N value of 16.5, and the lowest critical value in the Wilcoxon Table associated with this N value, for significance at 5% level, was 11. This implies T_2 was also not significant because it by far exceeds the relevant critical value.

A formular is available for converting the T values to z-scores (or standard scores). z-scores are the values obtained when a set of scores (x_i: x_1, x_2, x_3, ..., x_n) are expressed as deviations from the mean of the set of scores (x_i - $\bar{x}$) per standard deviation (s). In other words the z-scores is expressed as $z = (x_i - \bar{x})/s$. Coolican (1990) explained that the formula for converting the T values to z-scores is based on the assumption that if the test is performed many times on two sets of randomly produced ranks, the Wilcoxon T values would form near normal distributions. The location of any particular T can therefore be determined on that distribution in terms of a z-score. The relevant formula for converting the T values to z-scores were reproduced by Coolican (1990, p194) as

$$z = [N(N + 1) - 4T]/\sqrt{[2N(N + 1)(2N + 1)/3]}.$$

If the conversion is done, the exact probabilities for the likelihood of differences the size of T occurring, or the likelihood of expecting the positive and negative rank sums to be about equal under the null hypothesis, could be determined from the normal distribution table. The z-scores for the Wilcoxon 'T' statistic for the test for differences between the distributions of the extent to which content in topics are emphasised in the official curriculum and in teachers' instruction calculated with the aid of the SPSS computer software have been presented in Table 6.5b below.

Table 6.5b

Wilcoxon Matched-Pairs Signed-Ranks Test

(a)

I (based on teachers' self-rating of coverage) with $\boldsymbol{O_1}$ (based on counts of textbook pages)

Mean Rank	*Cases*
5.00	7 - Ranks (O_1 < I)
5.00	2 + Ranks (O_1 > I)
	7 Ties (O_1 = I)
	--
	16 Total
Z = -1.4809	2-Tailed P = .1386

(b)

I (based on teachers' self-rating of coverage) with $\boldsymbol{O_2}$ (based on counts of syllabus objectives)

Mean Rank	*Cases*	
6.19	8 - Ranks (O_2 < I)	
5.50	3 + Ranks (O_2 > I)	
	5 Ties (O_2 = I)	
	--	
	16 Total	
	Z = -1.4670	2-Tailed P = .1424

The smaller the value of T, the higher the probability, and, for that matter, greater the weight of evidence favouring rejection of the null hypothesis. Hence the null hypothesis is rejected if the corresponding z-score has a probability which is less than or equal to a predetermined level of significance, normally, $p \leq 0.05$.

Appendix 6. 5 Frequencies of instructions in activities in teacher's handbook suggesting classroom organisation under whole-class, individual and small group

Intended teacher-action in instruction	Frequency		
	Whole-class	Individual	Small-group
ask	25		
be	1		
discuss	1		
draw	2		
explain	1		
get	4		
give	2		
go	3		
guide	2		
let	7	9	2
point	2		
put	3		
question	1		
remind	1		
revise	1		
say	5		
tell	1		
work	2		
write	4		
TOTAL	**68**	9	2

Appendix 6. 6(a) The results of the test of differences among groups of teachers who mentioned, covered, or emphasised content in their mean ratings of frequencies of using the categories of teaching skills

	Motivational, small group and individual instruction, and thinking development skills		Communication skills		Presentation skills		Evaluative and teaching/learning resources management skills	
Teachers coverage of content in topic categories	Mean ratings	Pearson's χ^2 value[#]/ and *significance*[##].	Mean ratings	Pearson's χ^2 value[#]/ and *significance*	Mean ratings	Pearson's χ^2 value[#]/ and *significance*	Mean ratings	Pearson's χ^2 value[#]/ and *significance*
Basic number concepts		0.515		0.491		0.213		0.000
mentioned	-							
covered	2.05	*(0.472)*	1.90	*(0.483)*	2.04	*(0.664)*	1.42	*(0.986)*
emphasised	1.95		1.78		2.01		1.41	
Commercial arithmetic and data handling		0.094		3.094		0.798		2.866
mentioned	1.96	*(0.954)*	1.76	*(0.213)*	1.98	*(0.671)*	1.31	*(0.237)*
covered	1.95		1.80		2.11		1.39	
emphasised	1.83		1.85		2.06		1.41	
Geometric concepts		0.557		1.365		3.883		1.099
mentioned	1.96		1.72		2.02		1.27	
covered	1.96	*(0.757)*	1.84	*(0.505)*	2.03	*(0.143)*	1.40	*(0.577)*
emphasised	1.96		1.80		2.12		1.69	
Measurement concepts		1.885		2.081		5.500		0.454
mentioned	1.95		1.77		2.12		1.39	
covered	1.94	*(0.389)*	1.77	*(0.353)*	1.99	*(0.064)*	1.39	*(0.797)*
emphasised	2.16		1.96		1.85		1.50	
Number operations		0.270		4.658		0.769		2.571
mentioned	2.03		2.00		1.92		1.50	
covered	1.95	*(0.873)*	1.80	*(0.097)*	2.02	*(0.681)*	1.31	*(0.276)*
emphasised	1.97		2.00		2.03		1.45	

[[#]Values marked with * were observed at $p < .05$, significant level;
[##]Numbers in italics are significant values observed.]

Appendix 6. 6(b) The results of the test of differences among teachers (grouped by personal and organisational characteristics) in their mean ratings of coverage of the five topic categories: Tables 6.15-19

Table 6.15 Mean ratings for coverage of basic number and fractional concepts by personal and organisational characteristics

	Number of teachers	Mean ratings	Pearson's χ^2 value	Significance
Teacher's sex: female	51	1.85	2.650	-
male	83	1.73		
Length of teacher's teaching experience:			1.077	-
more than 3 years	101	1.81		
not more than 3 years	33	1.69		
Level of teacher's class: lower primary	43	1.86	1.846	-
upper primary	91	1.74		
Size of teacher's class:			0.312	-
not more than 35 pupils	56	1.79		
more than 35 pupils	78	1.77		
Teacher's participation in in-service			3.729*	$p < .05$
in-service courses ≤ 2	119	1.80		
in-service courses > 2	15	1.59		
Teacher's qualification in O'level mathematics:			4.238*	$p < .05$
without qualification	71	1.79		
with qualification	63	1.76		

Table 6.16 Mean ratings for coverage of Commercial arithmetic and data handling by personal and organisational characteristics

	Number of teachers	Mean ratings	Pearson's χ^2 value	Significance
Teacher's sex: female	27	.81	3.227	-
male	69	1.00		
Length of teacher's teaching experience:			1.012	-
more than 3 years	86	.97		
not more than 3 years	28	.89		
Level of teacher's class: lower primary	17	.82	2.024	-
upper primary	79	.97		
Size of teacher's class:			0.894	-
not more than 35 pupils	36	.86		
more than 35 pupils	60	1.00		
Teacher's participation in in-service			2.893	-
in-service courses ≤ 2	84	.90		
in-service courses > 2	12	1.25		
Teacher's qualification in O'level mathematics:			0.198	-
without qualification	47	.94		
with qualification	49	.96		

Table 6.17 Mean ratings for coverage of geometric concepts by personal and organisational characteristics

	Number of teachers	Mean ratings	Pearson's χ^2 value	Significance
Teacher's sex: female	39	.90	0.403	-
male	75	.95		
Length of teacher's teaching experience:			1.012	-
more than 3 years	86	.94		
not more than 3 years	28	.89		
Level of teacher's class: lower primary	33	.91	0.058	-
upper primary	81	.94		
Size of teacher's class:			1.748	-
not more than 35 pupils	50	.92		
more than 35 pupils	64	.94		
Teacher's participation in in-service			0.203	-
in-service courses ≤ 2	99	.93		
in-service courses > 2	15	.93		
Teacher's qualification in O'level mathematics:			0.081	-
without qualification	59	.88		
with qualification	55	.98		

Table 6.18 Mean ratings for coverage of measurement concepts by personal and organisational characteristics

	Number of teachers	Mean ratings	Pearson's χ^2 value	Significance
Teacher's sex: female	47	.89	4.785	-
male	81	.93		
Length of teacher's teaching experience:			0.538	-
more than 3 years	98	.93		
not more than 3 years	30	.87		
Level of teacher's class: lower primary	39	.79	6.290*	$p < .05$
upper primary	89	.97		
Size of teacher's class:			1.131	-
not more than 35 pupils	53	.98		
more than 35 pupils	75	.87		
Teacher's participation in in-service			0.985	-
in-service courses ≤ 2	113	.92		
in-service courses > 2	15	.87		
Teacher's qualification in O'level mathematics:			0.155	-
without qualification	70	.84		
with qualification	58	1.00		

Table 6.19 Mean ratings for coverage of number operations by personal and organisational characteristics

	Number of teachers	Mean ratings	Pearson's χ^2 value	Significance
Teacher's sex: female	47	1.70	3.212	-
male	77	1.58		
Length of teacher's teaching experience:			2.516	-
more than 3 years	93	1.67		
not more than 3 years	31	1.52		
Level of teacher's class: lower primary	39	1.90	14.350***	$p < .001$
upper primary	85	1.51		
Size of teacher's class:			0.870	-
not more than 35 pupils	51	1.68		
more than 35 pupils	71	1.59		
Teacher's participation in in-service			2.402	-
in-service courses ≤ 2	107	1.64		
in-service courses > 2	15	1.53		
Teacher's qualification in O'level mathematics:			1.375	-
with no qualification	66	1.67		
with qualification	58	1.59		

Appendix 6. 7 Ages[1] at which content is introduced in the primary mathematics curriculum in Ghana, England and the United States

Content area+	Age at which content is introduced in curriculum		
	Ghana	England	United States
Number concepts			
sets of numbers	5 - 6	-	-
recognizing, writing and ordering and numbers	5 - 6	5 - 6	5 - 6
place value	7 - 10	7 - 10	7 - 10
fractions	6 - 8	10 - 12	7 - 10
decimals	9 - 10	8 - 10	8 - 10
percentages	9 - 10	10 - 12	10 - 12
number patterns - even & odd numbers	9 - 10	*	7 - 8
prime numbers	10 - 11	12 -	11 - 12
HCF & LCM	10 - 11	*	11 - 12
square roots	11 - 12	*	11 - 12
approximations and rounding off	11 - 12	*	*
Computational skills			
set notation and operations	6 - 7	-	-
mental computations	-	6 - 7	6 - 7
basic operations with whole numbers	6 - 7	6 - 7	6 - 7
basic operations with integers (negative numbers)	9 -10	12 -	11 - 12
basic operations with rational numbers	9 - 10	10 - 12	9 - 10
use of letters	8 - 9	*	8 - 9
points on number line	6 - 7	*	6 - 7
points in number plane	9 - 10	11 - 12	9 - 10
Measurement			
concept and process of measuring, length, time, weight, area, volume and capacity	6 - 7	5 - 8	5 - 8
measuring of length, area, volume, and capacity using standard instruments	9 - 10	9 - 10	9 - 10
finding equivalencies of units	9 - 10	9 - 10	8 - 9
estimation of quantities	-	9 - 10	9 - 11
formula for area and volume	10 - 11	-	11 - 12
Geometry			
spatial sense including direction	5 - 7	5 - 7	5 - 7
recognizing, and constructing 2-D & 3-D shapes	6 - 7	12 -	7 - 8
building symmetrical patterns	-	8 - 10	8 - 10
using formal geometric notations to name lines and figures shapes	8 - 9	12 -	8 - 9
properties of 2-D & 3-D shapes including congruence	8 - 9	12 -	9 - 10
geometric movements	11 - 12	-	-
Commercial arithmetic and handling data			
ratio, proportion and rates	11 -12	12 -	11 -12
simple interest	11 -12	*	*
constructing graphs	8 - 9	7 - 8	7 - 8
averages	10 - 12	10 - 12	10 - 12
reading tables and graphs	9 - 10	7 - 8	7 - 8
probability	10 - 12	10 - 12	10 - 12
Real life applications and problem solving			
non-routine tasks and investigations	-	6 -	6 -
real life application of concepts.	8 - 10	6 -	6 -
Use of technology			
calculators	-	8 - 10	10 - 12
computers	-	10 - 12	10 - 12

[1] The age levels entered for England were based on those observed by Howson (1991), and for America were those indicated in the document - National Council of Teachers of Mathematics (1993).

+ [NOTE '-' in the table indicates the content is not at all taught at the primary level in that country, and '*' indicates content areas where the sources consulted -Howson (1991) and NCTM (1989) - provided no evidence of their inclusion in the curriculum at the primary level.]