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**A STUDY OF TRAINING PROGRAMMES FOR  
SCHOOL MATHEMATICS TEACHERS IN NIGERIA**

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## ABSTRACT

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This research set out to examine initial teacher training programmes for school mathematics in institutions in Nigeria with the aim of establishing their characteristics, quality and appropriateness. The focus of the study was the curricula of colleges of education and the understandings and expectations of student teachers at the terminal point of their training in these colleges.

The study sought to determine:

- a) the characteristic features of programmes that exist in Nigeria for the initial training of school mathematics teachers;
- b) the differences among the training programmes;
- c) the relationship between the training curricula and the school mathematics curriculum in Nigeria;
- d) the level of understanding of school mathematics subject matter among trainees who have completed the training programmes.

Data were collected and analysed from three sources to allow triangulation of findings. The first sought information from curricular provisions in initial training programmes, in terms of the knowledge components expected to be understood by a mathematics teacher. The second, a school mathematics contents test, was used to identify prospective teachers' level of understanding of school mathematics at the end of their training. The third, a questionnaire, was used to seek mathematics teacher trainers' views about the training programmes in their institutions.

The research drew the following conclusions:

- 1) There are differences between mathematics teachers training programmes in Nigeria. The initial teacher qualifications awarded by different colleges of education cannot, therefore, be said to be of the same quality.
- 2) Mathematics teachers training programmes in Nigeria are not achieving their intended objectives because there are contradictions between their stated aims and the curricular provisions for training.
- 3) The level of understanding of subject matter by prospective teachers in Nigeria is low. Over 30% of student teachers cannot be relied upon to teach the school mathematics syllabus with confidence.
- 4) There is low understanding among teacher trainers of the objectives and philosophy of teacher education in Nigeria. Most teacher trainers believe that the main purpose of training is to help student teachers develop enthusiasm and intellectual ability for further mathematics.

In summary, it is suggested that the curricula for training school mathematics teachers at colleges of education in Nigeria are not related to the subject matter of school mathematics nor to the needs of trainees and they need substantial revision.

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Special gratitude goes to my wife **Florence** whose endurance, understanding and encouragement stood behind this achievement.

TO GOD BE HONOUR, GLORY AND PRAISE. AMEN

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## DEDICATION

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TO

**MY GRANDPARENTS:**

Chief Anakwuo Okeke-Ogo (Akwuo-Nwazulu of Awka)  
Nnekwu-Ogodo Ekemma Anakwuo (nee Mbonu of Nnibo)  
Chief Eze Igwenagu (Amasiamasi Ifufe-apa-Ugwu I of Awka)  
Ojefi Mgbankwo Igwenagu (nee Ilodigwe of Amawabia)

**MY PARENTS:**

Engineer Chief Festus Nwachukwu Anakwue (Nwazuluaru)  
Madam Catherine Nwezelagbo Anakwue (nee Igwenagu of Umudioka-Awka)  
(Agbo eji eje mba I)

**MY WIFE AND CHILDREN**

Obidie Mrs Florence Nwamu Anakwue (nee Obuekwe of Umuzocha-Awka)  
Vanessa Chinyelu Obianamma Anakwue  
David Kenechukwu Anakwue  
Anthony Onyemaechi Chukwuemeka Anakwue  
Christopher Ikechukwu Anakwue

**MY COUSIN**

Juliet Nkechi Igwenagu

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**GLOSSARY OF INITIALS AND ACRONYMS**

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ALG	Algebra component of the NNMC
AMP	African Mathematics Programme
CESAC	Comperative Education Study and Adaptation Centre
CoE(s)	College(s) of Education
CPE	Certificate of Primary Education
DGK	Definitional and General Knowledge
FDS	Federal Department of Statistics
FGN	Federal Government of Nigeria
FME	Federal Ministry of Education
GCE	General Certificate of Education (Ordinary Level)
GCSE	General Certificate of Secondary Education
GEOT	Geometry and Trigonometry component of the NNMC
HNC	Higher National Certificate
HND	Higher National Diploma
INSET	In-service Education for Teachers
IPMSR	Intervention Panel for Mathematics Syllabus Revision of WAEC
JSC	Junior Secondary Certificate
JSCE	Junior Secondary Certificate Examinations
JSMC	Junior Secondary Mathematics Curriculum
JSS	Junior Secondary School
NCCE	National Commission for Colleges of Education
NCE	Nigerian Certificate in Education
NEDRC	National Educational Development and Research Council
NERC	National Education Research Council
NN	Number and Numeration component of the NNMC
NNMC	Nigerian National Mathematics Curriculum for schools
NNTEP	Northern Nigeria Teachers Education Project
NPE	National Policy on Education
NTI	National Teachers' Institute
ONC	Ordinary National Certificate
OND	Ordinary National Diploma
PS	Process Skill

PsAS	Problem solving and Application Skills
SMCT	School Mathematics Contents test
SSC	Senior Secondary Certificate
SSCE	Senior Secondary Certificate Examination
SSMC	Senior Secondary Mathematics Curriculum
SSMC(fm)	Further mathematics component of the SSMC
SSMC(gm)	General mathematics component of the SSMC
SSS	Senior Secondary School
STAT	Statistics component of the NNMC
TAMP	Teacher-trainers Assessment of Mathematics Programmes Questionnaire
TC2	Teachers' Grade two Certificate
UPE	Universal Primary Education
WAEC	West African Examinations Council
WASC	West African Schools Certificate

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## CHAPTER 1

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### BACKGROUND AND STATEMENT OF THE PROBLEM

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#### 1.1. Introduction

Since independence in 1960 Nigeria has, for various reasons, continued to expand her educational provision. The most spectacular expansions occurred between 1973 and 1980 following the introduction of the universal primary education at the national level in 1976; and again between 1990 and 1992 after the increase, from 21 to 30, in the number of semi-autonomous political states making up the federation and consequently the establishment of 9 new state ministries of education ( Adesina, 1993).

One unfortunate by-product of this expansion was thought to be the steady decline in the performance of students at public examinations in various school subjects (Omeni, 1992; WAEC<sup>1</sup> 1990, 1991, 1992, 1993 1994, etc.). This was to be blamed on teachers, particularly at the junior secondary school level, recruited by state ministries of education at various points to meet the demand created by the expansion (Yoloye, 1992). The goal of the federal government, since then, has been to raise teachers' skills at this level via two main routes: in-service programmes in English, mathematics, sciences and design and technology; and increase in the number of teacher training institutions in the country.

Unfortunately, the latter consisted of unplanned sequences of events culminating in the proliferation of colleges of education, some of which were described by Denga (1992) as "signboards carrying the names of the ambitious proprietor - usually a state or local

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<sup>1</sup> The West African Examinations Council (WAEC) with its headquarters in Accra, Ghana, is the body responsible for Secondary School Certificate (SSC) examinations for five former British colonies in West Africa; viz. Nigeria, Ghana, Sierra-Leon, Gambia and the Cameroon.

government or a community". So that, since 1990, one of the most pressing issues in Nigeria's educational debate has been the need to examine and harmonise training programmes at these institutions. This is because these institutions are responsible for preparing teachers for secondary schools in the country. (FME<sup>2</sup>, 1990; Omeni, 1992; Abatan, 1993; Ohunche, 1990; Lassa 1992; Fafunwa 1993).

The concern continued even after the curriculum harmonisation exercise ordered by the National Commission for Colleges of Education (NCCE) in 1991 through its Policy Document on Minimum Standard. This was because the academic community, industrial and political interest groups suspected that the harmonisation was "hushed-up" for political reasons and that secondary school teachers were still not properly trained; that they were not altogether competent to teach the contents of the national curriculum; that colleges of education, through their training programmes, were producing "subject matter incompetent graduates" (Ilori 1993).

The pressure was more pronounced in the area of mathematics teacher preparation because students' poor results in this subject in public examinations worsened over the years (FGN Chief Examiner's, Report 1994), heightening vigorous public concern and debate about the relevance and quality of mathematics teacher training programmes in colleges of education and attacks, such as that by Fafunwa (1993), the then Minister of Education, published and given substance by the Federal Ministry of Education, on mathematics teachers in Nigeria. Another reason was the special position occupied by mathematics in the country's education and employment services. For instance, entry to almost all university courses and other non-university professional training (e.g. accountancy) requires a credit pass in mathematics in the senior secondary school certificate examination of the West African Examinations Council or its equivalent.

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<sup>2</sup> Federal Ministry of Education, Lagos, Nigeria.



Given this situation, the need is clear for the educational community in the country to take stock of what is known and not known about teaching and learning and especially about the process of becoming a mathematics teacher in Nigeria. For instance, what programmes are in place for preparing teachers who are expected to help children learn mathematics as it is described in the Nigerian National Mathematics Curriculum (FME, 1982, revised 1990)? Is the claim that colleges of education, through existing programmes, are producing subject-matter incompetent graduates in fact valid? A good starting point, in this stock taking, would be to examine programmes employed in various colleges of education for preparing mathematics teachers for the secondary school level in order to see whether the programmes are relevant to school mathematics content or suitable for preparing teachers for their roles in schools in the country.

This, however, raises many questions. For example: What is meant by a suitable or relevant mathematics teachers training programme? What knowledge must such a programme aim to inculcate in trainee teachers? What kinds of knowledge do teachers need to become effective teachers of mathematics? What sorts of experiences are needed for teachers to acquire this knowledge? Is a relevant or suitable programme the same for all countries or are there other situational factors to be considered? What level of understanding of school mathematics by teachers makes them "subject matter competent"? What does it mean to be educated in order to become a teacher of mathematics? And of more fundamental interest to a researcher who sets out to investigate training programmes in colleges of education: how is teaching or the field of teacher education conceptualised so that existing programmes can be evaluated and compared to see if they are helping the trainees acquire the skills and knowledge that are intended.

Brown and Borko, (1992), tells us that research on becoming a mathematics teacher has been conducted from three perspectives: learning to teach, teacher socialisation and

teacher development. The learning-to-teach perspective includes research on teacher knowledge, beliefs, thinking and actions, with major emphasis within the discipline of psychology and grounded in the assumptions of cognitive psychology. One of these assumptions is that "good mathematics teaching" can be identified and described and, by implication, that it is possible to identify and describe the qualities of a good mathematics teacher and consequently activities and experiences that can be included in a programme for the training of such teachers. If this is accepted, it is then possible to identify, classify and analyse components of a mathematics teacher education in a training institution. And, thus, possible to describe and compare training programmes at different institutions, decide whether or not they are suitable and relevant and, more important, determine if they are, in fact, achieving the objectives of mathematics teacher education of the country as envisaged. The question, however, is: What is good teaching? What knowledge is essential for good teaching?"

Cognitive psychological theory states that knowledge is organised and structured and that teachers' thinking is directly influenced by their knowledge. Their thinking, in turn, guides their actions in the classroom, so that being properly trained (capable of rendering good teaching) entails the acquisition of a system of knowledge or schemata which will influence student teachers to think "correctly" about their discipline in order that their activities in a classroom are guided towards the best approach to help children learn the specific subject without difficulty. For example, being a well trained mathematics teacher (and by implication a good mathematics teacher) will entail the acquisition of essential knowledge systems or schemata, cognitive skills and observable teaching behaviours. A relevant training programme would, thus, be one that provides activities and/or experiences that enhance the acquisition of this knowledge system, skills and behaviours. The question is: what are these

teacher essential knowledge, skills or behaviours? In other words, how is teacher knowledge conceptualised?

Several theoretical models have been developed to represent teachers' knowledge systems and their cognitive processes. For instance, Shulman (1986) hypothesised that teachers draw from seven domains of knowledge - sets of cognitive schemata - as they plan and implement instructions. His research focused primarily on two domains: knowledge of subject matter and pedagogical content knowledge. It provided us with elaborate definitions of subject matter knowledge and pedagogical content knowledge. Shulman's analysis and his emphasis on pedagogical content knowledge has been particularly appealing to the field of mathematics education.

Bromme (1994) further differentiated Shulman's analysis by considering "both the concept of 'philosophy of content knowledge' and a clear distinction between the knowledge of academic discipline and that of the subject matter in school" and created a topology of teachers' professional knowledge that attends to the nature of mathematics. Also Ball (1990a) developed a conceptual framework for exploring teachers' subject matter knowledge specifically in the area of mathematics. She claimed that understanding mathematics for teaching, for instance, entails both knowledge *of* mathematics and knowledge *about* mathematics.

There are other variants of this conceptualisation (e.g. Lappan and Theule-Lubienski, 1994; Fennema and Franke, 1992; Behr, Harel, Post and Lesh, 1992; etc.). The unifying theme, however, is that teachers' knowledge base exists, is multi-dimensional and can be classified into identifiable domains.

It is certainly helpful, therefore, in determining the quality of training received by pre-service mathematics teachers in any situation, to study school mathematics teacher training

programmes in institutions in terms of the domains of mathematics teacher knowledge that are identified by research.

Furthermore, findings from several research ( e.g. Anderson, 1989; Scardamalia, 1987; Ball, 1990b etc.) confirm the importance of strong preparation in one's content area prior to teaching. What level of school mathematics content knowledge do prospective teachers in Nigeria possess? Such information will provide additional clues which will help in making decisions about the quality and relevance of training programmes for mathematics teacher education in the country - a question which, as was pointed out earlier, has been the subject of vigorous public debate in Nigeria since 1990.

However, in spite of its importance, in spite of public concern about it, in spite of official government acceptance that all was not well with mathematics education in the country (Fafunwa, 1991)<sup>3</sup>, there has been very little educational research bearing on the adequacy of mathematics teacher training programmes in Nigeria (Abatan, 1993). The assessments that exist (e.g. Ohunche, 1990; Omeni, 1992; Lassa, 1992, and so on) tend to be impressionistic.

It seems basically unsound to be expanding teacher education provisions, as is now the case in Nigeria, with so little knowledge of what teacher education programmes in the country are currently like. There is, therefore, need for a systematic study of teacher education programmes in that country. This study is an attempt to fill this gap. It is a survey of the institutionalised training programmes for pre-service teachers of mathematics in junior secondary schools (JSS) in Nigeria.

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<sup>3</sup> Alhaji Babatunde Fafunwa was the Minister of Education 1989-1992.

## 1.2. Purpose and scope of the study

The study set out to determine:

- a) the characteristic features<sup>4</sup> of programmes that exist in Nigeria for the initial training of school mathematics teachers;
- b) the differences among the training programmes;
- c) the relationship between the training curricula and the school mathematics curriculum in Nigeria;
- d) the level of understanding of school mathematics subject matter among trainees who have completed the training programmes.

The conceptual models of teacher knowledge explained earlier provided us with a framework with which to do this. For example, Shulman's domains of essential teacher knowledge provided us with a framework with which to define categories of teachers' knowledge and then classify and analyse contents of a mathematics teacher training programme according to these categories in order to be able to say whether or not, in general, a particular programme is or is not a "good or relevant programme". Ball's further differentiation of subject matter knowledge can then be applied to examine, in particular, the relevance (and quality) of the mathematics content of the training programme to the subject matter of school mathematics.

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<sup>4</sup> The '*characteristic features*' of a training programme, in the context of this research, are defined, in chapter 5 (section 5.2), in terms of three factors: presage, process, and product; and was taken to be concerned with the:

- entry requirement for candidates wishing to be trained for mathematics teaching;
- selection process for admitting the candidates for the course;  
level of education for which the teachers are being trained (i.e. target for graduates after training);
- method and mode adopted for training;
- length of time for which training was to be undertaken;
- total experiences of the student teacher in terms of the taught contents (mathematics, educational studies and pedagogical courses)
- actual behaviour expected of a trainee at the end of training and how this is to be measured.

The study was focused on training programmes at colleges of education (CoEs) in Nigeria because these colleges are responsible for training over 80% of the teachers for this level of schooling. It, therefore, examined the type and nature of training for teachers of mathematics - what was being done, how it was done and perhaps, reasons for doing it that way.

The decision to carry out this study was fuelled by two main convictions:

- (i) The place of the teacher is indispensable in education;
- (ii) unless systematic thought and research is devoted to the question of teacher education in a country, it is unlikely to achieve the quality in teachers expected by the education leadership in that country.

While acknowledging that there are several components of the teachers' knowledge (Carnegie Task force, 1986; Holmes Group, 1986; Shulman, 1986; Harel, 1994; Fennema & Franke, 1992; Grossman, 1990) the study takes the view that a central component of the effectiveness of secondary school teachers is what Boyer(1990) termed "their strong foundation on the knowledge taught". Shulman (1986) called it subject matter knowledge. The design of this study is, thus, pivoted on the premise that at the end of their training teachers must know whatever it is they are to teach. Or as Kerr (1981) rightly observed:

"...no matter how skilful one might be in getting students to learn things, the quality of one's teaching depends in important part upon one's understanding of the subject well enough both to choose appropriate learning and to design plans that do not violate the nature of the subject matter" (p. 81).

It is essentially for this reason that this study, in addition to attempting to identify trends in the training of junior secondary mathematics teachers in Nigeria, sought to measure

the level of prospective teachers' understanding of mathematics contents of the Nigeria National Mathematics Curriculum (NNMC) - *the content they are to teach* - at the terminal point of training at a college of education.

### 1.3. Research questions

Specifically, this study will attempt to answer the following six guiding questions:

- 1) What conditions or programmes exist for the training of school mathematics teachers in Nigeria?
- 2) In what respect do school mathematics teachers training programmes in Nigeria differ among themselves? In other words, if they differ how are they different?
- 3) In Nigeria, is there any relationship between the mathematics teacher training curricula and the school mathematics curriculum for which teachers are being prepared to implement?
- 4) What level of understanding of school mathematics subject matter in Nigeria do student teachers possess, at the terminal point of training, as their basis for teaching the NNMC?
- 5) Are there any differences between programmes in the level of subject matter understanding of student teachers passing out from different colleges of education in Nigeria?
- 6) In Nigeria, is there any relationship between curricula provisions for the training of school mathematics teachers and the needs of the trainee?

#### 1.4 Significance of the study

Concern is today being expressed in UK, USA, Australia and many other countries in western Europe about pupils' performances in mathematics in public examinations. Often the quality of teachers and their training is cited as a possible cause. Chris Woodhead's (1997) article, "*Why we must take back our schools*" in the *Reader's Digest* (Feb. 1997 pp 49-54), is but one example. Similar concern was also expressed about prospective teachers in Nigeria, by moderators from various universities after observing students on practice teaching for NCE certification. (Adepoju, 1991; Omeni, 1992).

Teachers are one of several indispensable elements in our educational system. Schools are no better and no worse than the teachers who strive to accomplish the goals set forth by those that have been given this responsibility. Teacher in-service is assumed to be preparing serving teachers for changes in mathematics contents and instruction through in-service workshops, college courses, and personal study. But what about prospective teachers, those that are now preparing for a career in teaching?

The adequate preparation of teachers in the mathematics now being taught in schools is, therefore, a natural next step after recognition of the need for a new mathematics programme. Continuation of teacher preparation for carrying out the new programme has many aspects that need to be explored. Two aspects that concern us in this study are the nature of training programmes and the relevance of the content of training to the subject matter of the school curriculum.

In identifying the general objective of any course for the training of teachers of secondary school mathematics, it must ensure familiarity with the materials and function of secondary school mathematics. We can never come to understand this unless we go out and find how prospective teachers are prepared and what they really know about the subject they will be expected to teach. It will be interesting, for instance, to know how



much mathematics background secondary school teacher in Nigeria have as their basis for teaching secondary mathematics.

Currently, initial training of teachers for the junior secondary level takes place in 53 colleges. Each college is affiliated to a university which develops and recommends a teacher training programme to it. Each of these validating universities has developed its own style of teacher training and a variety of different patterns of training has evolved as a result. Notwithstanding the value of institutional freedom in professional matters, and the value of variety and experiment in the curriculum of teacher education, there is a widely recognised need for agreed guidelines on the content of training, and a guaranteed level of preparation in the subject or aspect of the curriculum which a teacher offers to teach. One of the most pressing concerns today in Nigeria is, therefore, the need to consolidate, streamline and simplify programmes for preparing and upgrading teachers, which take into account Nigeria's particular requirements. These concerns underscore the significance of this study.

## CHAPTER 2

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### THE NIGERIAN CONTEXT

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#### 2.1. Introduction

In order to bring into perspective the significance of this study it is necessary to have some knowledge about three aspects of the Nigerian educational system: the educational structure, the development of the Nigerian school mathematics curriculum and the emergence of teacher education in Nigeria. It is hoped that this way the reader will be provided with background information without which it may be difficult to appreciate the present situation, the reason for embarking on this study, the rationale behind certain decisions made in the design of the study or the contribution of this study to mathematics education in general and mathematics teacher education in particular in the Nigerian context. What follows in the next three sections of this chapter, therefore, is relevant background information which it is thought a reader, not entirely familiar with educational provisions in Nigerian, needs in order to appreciate the place of the study in the present situation.

#### 2.2 The educational structure in Nigeria

Education in Nigeria followed the pattern established by the British until certain modifications in 1982. The system of education currently in operation in Nigeria is known as the 6-3-3-4 system; which numbers identify the number of years spent in successive phases of education in the country.

The child starts schooling at the age of six years and attends six years of primary school. Upon completion of primary school, the student is awarded the Certificate of

Primary Education (CPE) and is then moved to the junior secondary school (JSS) for a three-year programme. All students are expected to move from primary to junior secondary. There is no selection examination at the end of primary schooling.

Upon completion of the junior secondary school, students are awarded the Junior Secondary Certificate (JSC) on the basis of which their post-junior secondary education will be chosen. Each of the 30 states of Nigeria sets, administers and validates her own Junior Secondary Certificate Examination (JSCE). The Federal Ministry of Education's JSCE is for students of the 49 Federal Government Secondary Schools (Unity Colleges) owned, run and financed by the federal government. In a system such as this and given the pluralistic nature of the Nigerian society there is bound to be differing standards. That, however, does not concern us in this study.

On the basis of the JSCE, children's preference and interviews, students may continue their education in one of three types of post-junior secondary institutions: a further three years senior secondary school leading to the achievement of the Senior School Certificate (SSC)<sup>1</sup>; a five-year course of study at a teachers' college leading to a Grade II Teachers' Certificate (TC2)<sup>2</sup> or a three-year course of study at a craft/vocational school. The junior secondary is, thus, both a terminal point and a foundation for the senior secondary stage or teacher training. Students who choose to leave school at the junior secondary stage may also go on to an apprenticeship or some other scheme for out-of-school vocational training.

Students who pass the SSC examination with credit grades in at least five subjects (including English and Mathematics) may then continue their studies in a university where they would follow four-year courses leading to Bachelor's degrees. Senior

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<sup>1</sup> The SSC is awarded by the West African Examination Council (WAEC) and is considered to be higher than the former WASC/GCE "O" level but lower than the HSC/GCE "A" Level awarded by the same Council between 1963 and 1989.

<sup>2</sup> The Grade II Teachers' Certificate (TC2) is one of the non-degree level professional teacher training award qualifying the holder for primary school level teaching in Nigeria.

secondary school graduates who are unable to gain university places, for one reason or another (e.g. academic deficiency), may continue their studies in a college of education or a polytechnic.

On the other hand, students who enter Grade II teachers' colleges, after junior secondary school, if they pass their examinations for the TC2, with merit grades in the two core subjects (English and Mathematics) plus one more merit in any one of the options (e.g. science, nature study, social study craft etc.), may continue their education in colleges of education.

The college of education programme runs for three years, leading to the Nigeria Certificate of Education (NCE). The NCE is currently the highest non-degree level of professional teacher training qualifying the holder for primary and lower secondary levels of teaching. Badmus (1980) and later Omeni (1992) have, however, shown that because of shortage of qualified mathematics teachers, over 85% of NCE holders taught senior secondary schools classes in many schools. and that in most schools they constituted more than 90% of the teaching personnel in the mathematics departments.

After a few years of teaching, an NCE holder may continue his/her education at the university level for the BEd, BA(Ed) or the BSc(Ed) degree. This grade of teacher (the university trained graduate) teaches at the senior secondary school level. This study was concerned with the NCE teacher who constituted over 80% of school mathematics teachers in Nigeria.

Craft/vocational school graduates may continue their training at technical training centres for three years for the Ordinary National Diploma or Certificate (OND/ONC) and then qualify for further education at polytechnic schools (usually a further five-year course of study) for the Higher National Diploma or Certificate (HND/HNC).

The bulk of college of education intakes is thus drawn from two main sources: senior secondary school graduates and graduates of the Grade II teachers college who had entered training after their junior secondary education. The last constitute the majority of entrants to colleges of education (NCCE, 1994).

There are, however, exceptions to these two main groups (e.g. mature students who had normal entry requirements waived for them, and those who enter through alternate quick-entry routes). But these form less than one percent of the total college of education intake (Abatan, 1993) that it is not considered necessary to treat them as a separate group for the purpose of this study.

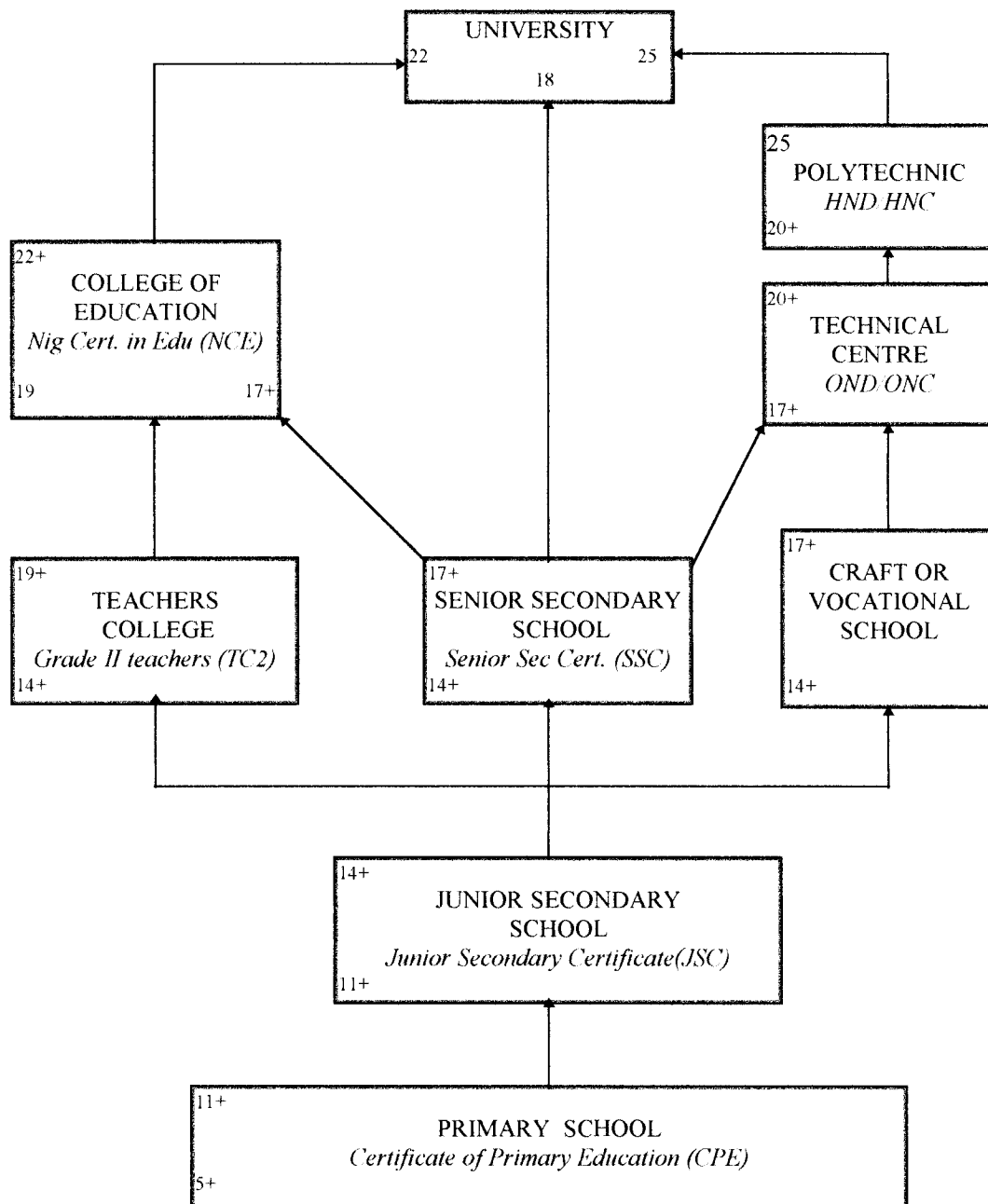
Schools' curriculum guidelines for the whole country are laid down in the 1977 (declaration of National Policy on Education (FME, 1977, 1981). The aims expressed include the promotion of national unity and accepted Nigerian values, with special emphasis on the achievement of universal primary education (UPE) as well as on agricultural, technical, special and teacher education. The National Education Research Council (NERC)<sup>3</sup> deals with schools curriculum research and development for the whole country, but state governments have introduced their own curricula, especially in science and language at the primary school level.

In 1982, Nigeria adopted a national mathematics curriculum NNMC (FME, 1982, 1990). This curriculum is in current use in all schools in the country and is examined by WAEC for SSC certification. The school mathematics contents test (SMCT) used for gathering part of the data for this research is based entirely on the subject matter of the NNMC. The curriculum is discussed in the next section. Figure 1.1 shows the structure of the education system described above.

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<sup>3</sup> Now renamed National Educational Development and Research Council (NEDRC)

Figure 2.1: THE EDUCATIONAL STRUCTURE IN NIGERIA



### **2.3. Development of school mathematics in Nigeria**

Mathematics in Nigeria, before 1963, was based on two syllabi recommended to schools by the universities of Cambridge and London in Britain. The two universities were the examining bodies and awarded, respectively, the London G.C.E and the Cambridge School Certificates. Teachers whose only objectives were to produce students capable of gaining admissions to higher institutions (all of which were in Europe and America) adhered diligently to the recommended syllabi. School mathematics in Nigeria, prior to 1963, could therefore be said to be dominated by ideas from the two examining institutions.

The first move to seek local opinion in drawing up school mathematics syllabus in Nigeria was in 1949 when the West African Examinations Council (WAEC) was established. The main purpose of the council was to gradually take over from the British universities the responsibility of examining the pupils in the schools of West Africa and progressively adapt the scheme of the examination and syllabi to the emerging needs of the areas served by it. In 1963 the major responsibility of awarding the school certificate was transferred to the council.

The only visible effect of the creation of WAEC on school mathematics curriculum (as indeed on other school subjects) was that instead of two syllabi being handed down from Cambridge and London, one syllabus was drawn up in Accra in Ghana (the headquarters of WAEC) and sent to schools in areas served by it. The syllabi adopted by WAEC between 1949 and 1963 were not significantly different from their predecessors from London and Cambridge. They were an amalgam of topics from both syllabi. Teachers in Nigeria, possibly because of their poor background, never questioned this influence. In fact, most welcomed the guidance given in the detailed

syllabi distributed to schools by the council. So that, for a long time it was assumed in Nigeria that the content of school mathematics was sacred and unalterable.

The second attempt was in 1963. It came as a fallout of the reform movement, initiated in Africa by the Massachusetts Institute of Technology through the African Mathematics Programme (AMP). After the AMP workshop at Entebbe, WAEC was to invite teachers from local schools, for the first time, to join its Intervention Panel for Mathematics Syllabus Revision (IPMSR).

The panel influenced many changes in school mathematics. The most significant of these was its recommendation that WAEC should consider, and if suitable examine, special mathematics syllabi submitted to it by countries or groups of schools served by it. This innovation enabled countries (such as Nigeria) and schools (such as Comprehensive School at Aiyetoro, Christ School at Ado-Ekiti and International School at Ibadan) to embark on some fruitful mathematics reform projects without being inhibited by external examination demands.

Following this Nigeria in 1971, through the Nigeria Education Research Council (NERC)<sup>4</sup>, in conjunction with the Federal Ministry of Education and WAEC, developed a “modern mathematics” programme to be used in schools all over the country. However, under pressure from such wide oppositions as parents, academicians, employers and teachers, the federal government withdrew the modern mathematics programme in 1977. The minister responsible for education at the time announced to a shocked Conference on Mathematics Education in Nigeria, meeting in Benin in January 1979 that:

“...modern mathematics offered at the moment will be abolished, *traditional mathematics will be reinstated* (italics mine), and the

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<sup>4</sup> Now renamed Nigeria Educational Development and Research Council (NEDRC) in 1992



government envisages that 1978 will be the last year that modern mathematics will be offered in school certificate examination in the country..." (Ali, Col. 1977)

In response, the Benin Conference,

1. affirmed that the teaching of mathematics is and should be a continuous process from the primary through to the secondary school;
2. urged that, in the light of this and in the light of the national objective for mathematics education, a thorough reappraisal of the existing curricula should be initiated immediately with a view to programming the mathematics syllabus to suit the planned 6-3-3-4 educational system, while at the same time maintaining a pedagogical continuity;
3. recommended (a) that the Federal Government should give a lead by co-ordinating the works of various curriculum development organisations in the country (e.g. CESAC, NERC, NNTEP, etc.)<sup>5</sup>; funding these organisations adequately to enable them produce a curriculum which could meet the national objectives. (b) that the Federal Government launched a special scheme for producing, retaining, encouraging and upgrading teachers of mathematics;
4. urged the Government to help teacher training colleges and secondary schools to set up mathematics laboratories. (Nwosu, 1978)

The Benin conference is now generally regarded as the beginning of the third and genuine attempt by Nigeria to reform her school mathematics programmes. The first and second failed because teachers were neither taken into confidence nor involved in its planning and development ( Nwosu, 1978; Badmus, 1992). This third attempt was initiated by delegates (over 80% of whom were mathematics teachers in secondary schools in the country) at the Benin conference.

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<sup>5</sup> Definitions of abbreviations are given on pages 5 and 6 of this thesis.

At subsequent conferences workshops, task forces, panels, committees, critiques, were planned, organised and held in various locations in Nigeria from 1977 under the auspices of the Nigerian Education Research Council

“to develop a school mathematics curriculum that will take into cognisance the needs of the child, the needs of the nation (Nigeria) and the purpose of education at each level as outlined in the National Policy on education” (NERC, 1977)

The outcome of this nation-wide consultation is the Nigeria National Mathematics Curriculum (NNMC) which came into use in all schools in Nigeria in January 1982. The curriculum was later revised in 1990. (see Appendices A-1 and A-2)

Before the adoption of this curriculum in 1982, mathematics at the primary school level consisted of arithmetic - pupils' mechanical manipulation of numbers and signs with little understanding of the processes involved. At the teacher training colleges “the mathematics consisted mainly of arithmetic because, it was argued, the students were being trained to teach elementary school arithmetic and, therefore, only needed arithmetic process” (Lassa, 1977). The secondary school mathematics, however, did go a bit beyond only arithmetic, and included algebra, geometry and trigonometry, but these were taught as separate subjects. WAEC, in fact examined them singly in three separate papers.

However, the new Nigeria National Mathematics Curriculum (NNMC) represents a clear departure from this. It is a product of conscious and painstaking attempts to achieve or create worthwhile and meaningful mathematics curricula.

Among its essential characteristics are:

- (a) Its layout has five headings: -topic, objectives, content, activities/materials and remarks.
- (b) The integration of all the relevant and useful ideas from the so-called 'modern' and

'traditional' mathematics. (The curriculum avoided the artificial separation of 'modern' and 'traditional' mathematics topics. For instance, while set theory ideas have been used as the building blocks, abstract formulations of set theory, which had tended to confuse issues, is eliminated).

- (c) The attempt, as much as possible, to relate mathematics to other subjects as well as to everyday activities.
- (d) Its presentation of contents as activity packages: various essential activities leading to the mastery of concepts are specified more than ever before; it provides useful guides to the teacher without the slightest suppression of his initiative.
- (e) The syllabus is divided into two levels:
  - (i) the junior secondary mathematics curriculum(JSMC) for the first three years of secondary education in Nigeria; and
  - (ii) the senior secondary school mathematics curriculum (SSMC) for the last three years of secondary education in Nigeria;
- (f) The SSMC is split further into two sections:
  - (i) The General mathematics [SSMC(gm)] and
  - (ii) The Further Mathematics [SSMC(fm)]

The SSMC(gm) is designed to provide a background of mathematical thought and a reasonable level of technical ability for those not wishing to take mathematics at higher level. It is intended to provide a sound mathematical basis for those students whose main interest lie outside the field of mathematics, for example, those planning to pursue further studies in such fields as accountancy, economics, geography and business administration. The programme, therefore, concentrates on using mathematics in contexts related, as far as possible, to other curriculum

subjects, to common general world occurrences or to topics that relate to home or work situations. This is in consonance with the two main objectives of mathematics education in Nigeria, namely: to enable the learner acquire functional skills to cope with the related problems of his world of work and to enable the less able learner cope with school mathematics.

The SSMC(fm) is intended for students with competence and high interest in mathematics who intend to specialise in mathematics at the university. It is geared towards: (i) helping students to develop conceptual and manipulative skills in mathematics so as to prepare them for further studies in mathematics and its application; (ii) reflecting continuity with the mathematics in the university and other tertiary institutions, so that graduates of the syllabus have nothing to unlearn on entering these institutions and (iii) preparing potential mathematicians, engineers and scientists for further studies.

Students taking the SSMC(fm) were not to take the SSMC(gm) and vice-versa. This rule has been glossed over recently and most students enter for papers in both syllabi in the senior school certificate examinations. The two papers are, however, not counted as separate subjects for the purposes of entry into higher institutions.

(g) The mathematics areas covered in the JSMC are:-

Number Numeration

Algebraic processes

Geometry and trigonometry

Everyday statistics

those in the SSMC are:

Number and numeration

Algebraic processes

## Plane geometry and Trigonometry

## Statistics and Probability

- (h) There is a natural link between the primary school teaching and the junior secondary school materials. This, it was intended, should make the transition from primary to secondary as smooth as possible.

The school mathematics contents test (SMCT) designed for this study is based on the JSMC and the SSMC(gm). This is because:

- (i) the JSMC is compulsory at the JSS level;
- (ii) the bulk (nearly 98%) of senior secondary students take the SSMC(gm) programme [WAEC Report, 1994];
- (iii) the subjects of this research (NCE mathematics student teachers) are certain to teach both the JSMC and the SSMC(gm) courses on graduation.

There has been a series of attempts to introduce the subject matter of the new curriculum through INSET courses to teachers already teaching in secondary schools in Nigeria (NTI<sup>6</sup>, 1990, 1991, 1992, 1993 and 1994). This has not, however, been the case with pre-service teacher programmes. There has not been a consistent effort to critically examine programmes in colleges for the education of pre-service mathematics teachers (Waziri, 1991).

Under the "Affiliation Scheme", imposed on colleges of education by the federal government in 1976, universities are associated with colleges in their training programmes. These "validating universities" assisted the colleges in curricular developments, moderation of examination papers and in monitoring their progress.

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<sup>6</sup> The National Teachers Institute (NTI) at Kaduna is responsible for INSET courses and publishes details of courses available for serving teachers at the beginning of each year-January.

Each college, however, retained the freedom to decide on the choice of activities and experiences to be included, the design of its own programme and method of assessing its students. This resulted in a variety of different patterns of training and, of course, differing standards.

In 1991, in an attempt to redress this, the National Commission for Colleges of Education (NCCE) through its Policy Document on Minimum Standards urged colleges and validating universities to ensure that all teacher education programmes “met the country’s educational needs as outlined in the National Policy.” The outcome is the adoption of what is currently referred to as “harmonised syllabuses” by each group of colleges affiliated to a particular validating university - a sort of localised common teacher training programmes. These efforts are, however, limited in the sense that a so-called harmonised syllabus can be prescribed by the validating university only to colleges affiliated to it. This way there are still today at least as many designs of training programmes as there are validating universities.

The concern expressed by Nigerians about the quality of these programmes is premised on the fact that standards in pupils’ performance in mathematics has fallen and is getting steadily worse. This view is shared by the national examination committee for this subject. The view is that pupils’ performance in this subject is getting worse because while mathematicians and mathematics educators are working together to provide strong mathematics texts for students at all levels, the teachers who are expected to implement those texts are being nurtured on programmes that, at best, are oblique to the task they are facing in the classroom. This was exactly what happened in the 1960s when Nigeria attempted to introduce the so-called “modern mathematics” into the school curriculum and failed. There is, therefore, good reason to be concerned for the background knowledge of teachers in mathematics for the new syllabus.

#### **2.4. Emergence of teacher education in Nigeria**

This section gives a brief history of teacher education in Nigeria. This is necessary so that the reader may appreciate the evolution and nature of professional teacher preparation programmes in the country and hence the significance of this study.

Western education was first introduced into Nigeria by missionaries. This group derived religious satisfaction in converting people to Christian religion. Their objective was to find people who would read the Bible and teach religious knowledge. The emphasis on education was therefore on how to read, write and spread Christian religions. This necessitated the training of Nigerians who could read, write and teach the Bible. Nigeria's first indigenous teachers of Western education were thus the catechises.

When the explorers with economic interests came onto the scene, the emphasis was again on getting Nigerians who were sufficiently literate to serve as interpreters to and clerks for the foreign traders. This also necessitated the training of a new group of Nigerians, who could read, write and do simple computations to be able to keep records of trade transactions. They were later employed to teach newly recruited employees and became, in a way, Nigeria's second batch of indigenous teachers. It can, therefore, be concluded that one phenomenon in the educational policy of both the missionary and the early foreign explorer-traders who were the forerunners in introducing education to Nigeria is the absolute orientation towards the need to produce literate Nigerians to serve their own ends. Teaching, as a profession, which resulted from their educational policy was only accidental. The educational policy of the British administrators with their indirect system of Government did not show any significant departure from that pattern either. Clerks were needed to collect taxes and interpreters were equally in demand to disseminate Government directives to the chiefs and natural rulers.

The 19th century however, witnessed a period of government intervention in education in the country. This took the form of giving grants in aid to the missionary schools and quality control by making use of inspectors. Educational policy during this period remained as before, except that education started to be seen as a tool for living. Even up to the early part of the 20th Century, educational policy continued to be based on the immediate needs of our colonial rulers. Here, it is pertinent to quote Lord Lugard's conception of the aim of Education in Nigeria in 1921.

"The chief function of government primary schools among primitive communities is to train the more promising boys from village schools as teachers for those schools, as clerks and interpreters for the local courts". (Fajana, 1975).

Thus, in the view of Lord Lugard, Nigeria was, some 76 years ago a "primitive community". Astonishingly, he was also of the opinion that only the "promising" boys were to be educated, while education was to be exclusively for boys. Little wonder then that between the Catechist/teacher or clerk/teacher and the formally trained professional teacher even at the elementary level there was a large gap.

However, opportunities were created for formal and informal professional teacher training programmes. First there were the *probationary teachers*: this category of teachers consisted of primary school products who were sent to serve in the classrooms for a number of years after which they enrolled for further teacher training.

At the turn of the century, a number of formal teacher education programmes emerged. The probationary teachers were requested to go to preliminary training institutions for a two- year programme leading to the award of the *Grade III teachers* certificate after which the teacher taught for three years before enrolling for the "Higher Elementary" teachers programme for the *Grade II Teachers* certificate (TC2).



After the Grade II teachers' certificate the graduate was expected to aspire to the *senior teacher* status. There were no specific institutions for training the senior teacher. The aspiring teacher was expected to take external examinations set by the Federal Department of Education and then would be inspected for teaching competence by inspectors appointed by the department.

Towards the early part of the sixties, the senior teachers were soon eclipsed by a new-breed of teachers: the *Grade 1 teachers*. These are those who had passed, beyond Grade II teachers certificate, two subjects at the General Certificate of Education "A" level (GCE "A" level) together with teaching practice. Again, a number of problems emerged with regard to the grade 1 certificate. The first was that the certificate took a long time to acquire because after passing the examinations there were long delays in arranging for teaching practice. Also the Grade I teachers discovered that their certificates could not gain them entrance into the University. There was also the fact that more and more grade 1 teachers preferred to operate in the secondary schools and the primary teacher training colleges than in the primary schools for which they were originally prepared.

There was also a group of teachers called *Pivotal teachers*. By definition a pivot is a person or thing that chiefly determines the direction or effect of something; or an essential component of a system, organisation or institution. What made these teachers pivotal was not clear to teacher educators themselves. By qualification, the pivotal teacher, however, was one who held the Grade II teachers' certificate and later passed, in addition, three other subjects at the General Certificate in Education Ordinary Level (GCE 'O' level). It could also be a West African School Certificate (WASC) holder who went through a two year education programme in any of the teacher's colleges. Initially, the pivotal teacher was very popular not only because he could teach at both the primary and secondary level but also because he could be called a tutor rather than a teacher. But as pivotal teachers

recognised that their programme was of a terminal nature more and more ceased to be pivotal and pursued programmes that would lead to further education.

This brief review of teacher education in Nigeria will not be complete without reference to the Associateship Diploma programme in Education. The idea about the Associateship programme originated from Britain where a number of Nigerians obtained the University of London Institute of Education's Certificate in Education. Almost immediately a high standard was accorded to the certificate and in 1957 the Institute of Education at the University of Ibadan decided to introduce something similar.

Today, almost all Nigerian Faculties and Institutes of Education run the Associateship Diploma Programme primarily to produce teachers that will strengthen the quality of primary education. However, the Associateship Diploma, compared to the London Certificate, fell very short in academic standard and took several forms with confusing interpretations. (Adesina, 1993). First, whereas the products of this programme were intended for primary schools, the Ministry of Education and the Schools Management Boards deployed them to secondary schools where they experienced serious difficulties of adjustment. Because the Ministries of Education utilised the Associateship diploma holders in secondary schools, the Universities themselves began to make the programme reflect some secondary school needs and introduced the teaching of subject content into the programme. In fact in Lagos and Ibadan Universities, students in this programme were allowed to specialise in certain areas such as Physical and Health Education, Special Education, Science and Mathematics, Social Studies, and so on. In some other Universities the Associate Diploma programme was confused with other diploma programmes in special areas that last two years, such as the Diploma in Mathematics Education at Ahmadu Bello University Zaria or the Diploma in Special Education at the University of Jos. The question of what standard to accord the two-year and the one-year programmes are still unresolved. What is certain is

that the original intention of the Associateship programme is lost and various institutions are tinkering with the contents and objectives of the Associateship programme.

Perhaps the most revolutionary programme among all the innovations in teacher education in Nigeria is that of the NCE teacher - the subject of this research. The Federal Government of Nigeria established, more than thirty years ago, the Advanced Teachers' Colleges (ATCs) - now called Colleges of Education (COEs) - on the recommendation of the Ashby Commission on post-School Certificate and Higher Education. The main objectives for establishing the colleges of education are two fold:

"To streamline and simplify the large and confusing number of different grades of teachers existing at the time, in order to be able to harmonise teachers' condition of service and remuneration procedure.

To produce, quickly and in large number, teachers who do not possess university degrees but who would be needed to strengthen the teaching force (woefully in short supply after the recent expansion in educational provisions in the country) at the primary and lower secondary school levels and the Grade II teacher training institutions."  
(FGN, 1963)

However, evidence (Badmus, 1980; Omeni, 1992) have shown that the second objective has disappeared. A negligible percentage of college of education products (the NCE Teacher) opt for service in primary schools and over 85% now teach senior secondary schools classes.

The NCE is awarded to students who successfully complete a three year post-senior school certificate (or post-Grade II teachers' certificate) teacher education programme in a college of education. It is the minimum qualification for secondary school teaching in Nigeria.

Beyond the NCE, Nigerian universities offer courses leading to BEd, BA(Education) or the BSc(Education) degrees for teachers who wish to teach post-junior secondary programmes at

the senior secondary schools or post-secondary institutions (e.g. colleges of education).

## CHAPTER 3

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### LITERATURE REVIEW

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#### 3.1. Introduction

The nature of teachers' knowledge, of which mathematics teachers' knowledge is a part, has been debated at least in the last two decades and probably even before. These philosophical debates centre on questions like: "What kinds of knowledge do teachers need to become effective teachers of mathematics?" and "What sorts of activities and experiences are needed for teachers to acquire this knowledge?" In chapter one, it was argued that if we can find answers to these questions it may be possible to examine current practices in initial teacher education to see if training programmes can provide a secure base from which student teachers can become effective teachers of mathematics. The goals of this chapter are, therefore, twofold: to review research related to characterising teacher knowledge and to discuss implications of this for teacher education and for the design of this study.

There is no consensus among researchers as to the knowledge necessary to ensure that a mathematics teacher is effective. Many components of teachers' knowledge have been identified. Some scholars suggest that since one cannot teach what one does not know, teachers must have in-depth knowledge not only of the specific mathematics they teach, but also of the mathematics that their students are to learn in the future. Only with this in-depth knowledge of mathematics can a teacher know how to structure his or her own mathematics so that students continue to learn. Others suggest that knowledge of cultural and ethnic diversity is essential for effective teaching. For instance, since Nigeria is a multi-ethnic society, and since a student's ethnicity or culture is a major determinant of how the student learns (D'Ambrosio, 1984, 1985; Nunes, 1992), before a

teacher can be effective in Nigeria, he or she must understand the ethnic and cultural diversity of the students in that country. Still others suggest that knowledge of how students think and learn is vital for teachers, while others believe that knowledge of general pedagogical principles is a necessary component of teacher knowledge. Is there then information that can be gained from research that will help us to identify the critical components of teacher knowledge? Can past research indicate directions that would help us examine mathematics teacher education programmes in any way?

While many have speculated on the components of teacher knowledge, only a few components have received major attention from researchers: content knowledge, pedagogical content knowledge, general pedagogical knowledge, knowledge of the environment and practical skills.

### **3.2. Content knowledge**

Within mathematics education, there exists much rhetoric that reflects strong beliefs about the importance of content knowledge to teachers. One of the most widely offered explanation of why students do not learn mathematics is the inadequacy of their teachers' knowledge of mathematics. For instance, in a study in Nigeria by Omeni (1992) to ascertain which branches of mathematics students find difficult in senior secondary schools and why, as many as 86% of the student respondents attributed their difficulties in algebra and three dimensional geometry to their teacher's limited knowledge of these topics. She was also to find that teachers are "prone to take the line of least resistance by teaching only those topics that they can handle easily" and "as a result, the content of three dimensional geometry was hardly ever covered in most schools in Nigeria." In a similar study, Adepoju (1991) was to identify inadequate teacher knowledge of content as "the reason given by most respondents as the greatest

factor affecting the performance of students in mathematics in Nigeria”, and concluded that “mathematics teachers in our primary and secondary schools are made up of:-

- (a) those teachers who do not know enough mathematics and do not know how to teach;
- (b) those teachers who know how to teach but do not know mathematics;
- (c) those teachers who know mathematics but do not know how to teach; and
- (d) those teachers who know mathematics and can teach mathematics.”

He estimated that those in category (a) are in the majority, followed by those in (b) , then (c), and finally, but sadly (d). In other words, “the least competent teachers are those teaching mathematics in our schools”. He cited Yoloje(1990) to show that the majority (about 57.5%) of these were recent graduates of colleges of education in Nigeria. On the premise that a person cannot reasonably be expected to teach something which he himself does not fully comprehend, Adepoju called into question the adequacy of mathematics teacher training programmes in Nigeria and recommended that further research is needed to find out whether, why and how colleges of education or mathematics teacher education programmes are failing in their tasks.

Also debates about the quality of pre-service teachers in Nigeria were because of public concern about students’ poor performances in mathematics. Similar explanations were suggested in the current debate in UK for poor students’ performance in mathematics. And in the USA certification requirements for secondary school teachers almost always list the number and type of mathematics courses that must be completed before a person is allowed to teach.

Underlying these attitudes is the belief that content knowledge is critical for teachers before they can help students learn. The belief is shared by scholars in the field. This is evidenced in the amount of research devoted to appraising teacher content

competence. For example, work with pre-service primary school teachers (e.g. Graeber, Tirosh and Glover, 1989; Mangan, 1986; Harel, Beher, Post and Lesh, 1985) which show that primary school teachers possess the very same misconceptions that have been identified with children. Like children's knowledge, pre-service and in-service teachers' knowledge include beliefs that are incongruent with the multiplicative operation of rational numbers; e.g. "multiplication makes bigger" and "division makes smaller."

Post et al (1988) investigated 218 intermediate grade teachers' knowledge about the conceptual underpinnings of rational numbers and concluded that 20 to 30 percent of the teachers knew less than 50 percent of the items on the overall instrument. And Harel (1994) reported that his research indicated that "teachers' mathematics knowledge is below even the level expressed in the recommendations of the US Southern Regional Educational Board's standards for high-school students".

Other studies focusing on a variety of subject areas including history (e.g. Wilson, 1987), science (e.g. Carlson, 1990), English (e.g. Grossman, 1987), biology (e.g. Hashew, 1987) have also provided evidence that teachers' knowledge of content affects both the content and the process of their instruction, influencing both what they teach and how they teach; that teachers with more explicit and better organised knowledge tend to provide instruction that features conceptual connections and meaningful student discourse. On the other hand, teachers with limited knowledge of content tend, in the words of Stein et al (1990), to

“...portray the subject (mathematics) as a collection of static facts; to provide impoverished and inappropriate examples, analogies, and/or representations; and to emphasise seat-work assignments and/or routinised student input as opposed to meaningful dialogue” (Stein, Baxter and Leinhardt, 1990)



In general, research suggest that teachers knowledgeable in the subject matter of a discipline are better able to detect student preconceptions, to exploit opportunities for fruitful digression during teaching, to interpret insightful student comments, and to emphasise conceptual understanding. And, conversely, teachers with inadequate (or less) knowledge of content may reinforce student misconceptions, may inappropriately criticise correct student response, may avoid teaching critical materials altogether if they do not know it well, and may be unable to appraise critically the adequacy and accuracy of relevant texts. These teachers also tend to emphasise didactic lecturing to avoid the embarrassment of difficult questions.

In spite of the beliefs in the importance of mathematical knowledge and the evidence that some teachers do not have adequate knowledge of mathematics, research has provided little support for a direct relationship between teachers' knowledge of mathematics and students' learning. Historically the debate over the issue has been on ideological rather than empirical grounds. However, there has been a huge amount of work on the issue in the last two decades. Evidence seem to favour the notion that while subject matter knowledge is an important prerequisite for effective teaching, it is not sufficient in and of itself. For instance, while some (e.g. Darling-Hammond 1991); conclude that there is little evidence to lead one to suggest a relationship between the amount of mathematics studied by teachers and student learning, others (e.g. Brown, Cooney and Jones, 1990; Ball and McDiarmid 1990; Ball, 1988; Post, Harel Behr and Lesh, 1988; Harel, 1994 etc.) support the assertion that a thorough grounding in subject matter is essential in the preparation of novices for teaching as well as the argument that subject matter knowledge makes a difference in teaching. In fact Ball and McDiarmid (1990) state that there is empirical support that subject matter knowledge positively affects mathematics teaching and learning. In Druva and

Anderson's (1983) meta-analysis science courses were positively associated with successful teaching. Hawk, Coble and Swanson (1985) offer further support in their finding of negative effects for mathematics instructors teaching out of their fields.

However, regardless of one's viewpoint on the relation of mathematics knowledge and teaching effectiveness it is still the case that students' failure in mathematics is, first and foremost, blamed on teacher inadequacy. The current debate in UK on education standard is a case in point. The first answer to the question: "Why are students failing mathematics?", is usually (and before any thought of research or hard evidence) "Standards of teaching have fallen". It seems quite reasonable, in the face of this tendency to blame students' failure on teacher inadequacy, to expect programmes designed for training school mathematics teachers to be positively oriented towards inculcating adequate content knowledge. This need is exacerbated in the case of Nigeria where, according to Omeni (1992), "the populace is largely uninformed about outcome of research in education" and where, the popular belief is that teacher quality has declined since the emergence of what Denga(1992) called "mushroom colleges of education".

What, however, is content knowledge? Grossman and Shulman (1988) defined content knowledge as knowledge of the subject matter of a discipline. It consists of the key facts, concepts, principles and explanatory frameworks in a discipline, known as substantive knowledge, as well as the rules of evidence and proof within that discipline, known as syntactic knowledge. In mathematics, for example, substantive knowledge includes mathematical facts, concepts and computational algorithms; syntactic knowledge encompasses an understanding of the methods of mathematical proof and other forms of argument used by mathematicians. Ball (1990a), who developed a conceptual framework for exploring teachers' subject matter knowledge specifically for

mathematics, characterised mathematics content knowledge as comprising both knowledge *of* mathematics and knowledge *about* mathematics. Knowledge of mathematics is closely related to Shulman's dimension of substantive knowledge. To teach mathematics effectively, Ball argued:

“...individuals must have knowledge of mathematics characterised by an explicit conceptual understanding of the principles and meaning underlying mathematical procedures and by connectedness - rather than compartmentalisation - of mathematical topics, rules, and definitions”.

(Ball, 1990)

Knowledge about mathematics is related to Shulman's dimension of syntactic knowledge, and it includes an understanding of the nature of knowledge in the discipline - where it comes from, how it changes, how truth is established, and what it means to know and do mathematics. Harel (1994) refer to content knowledge as “the breadth and, more importantly, the depth of mathematical knowledge possessed by the teacher” and insists that “it is a crucial component because it affects both what (the teachers) teach and how they teach it”

And in an attempt to specify what knowledge is essential to teaching mathematics, Hilton (1990) claims that “there are features common to all worthwhile mathematics that should be brought out” and that “it is unreasonable to anticipate a revolutionary change of mathematical content - or, rather, intended mathematical content - at the secondary level” (p.135). Then, on the assumption that every secondary curriculum shows an awareness that we are living in the computer age, Hilton goes on to present what he called “crucial contents” of a mathematics teacher education programme under five heads: algebra, geometry, number systems, functions and rate of change, and finally applications. He then prescribes, under each heading, what he insists is the “minimal reasonable duties” for the secondary mathematics teacher as follows:

- Ability to execute significant algebraic manipulations and understanding of why they are significant.
- Ability to think geometrically (in two and three dimensions) and the ability to prove geometrical statements both synthetically and analytically.
- An understanding of how, why and with what consequences the number system is built up, starting with the natural numbers.
- A clear, even if essentially intuitive, notion of function and rate of change.
- An understanding of the role of application in simulating mathematical activity and in simulating the study of mathematics.”

Hilton, however, warned us that these should not be seen as separate courses, but must be treated as essential features of a “well-rounded mathematics teacher education”

Content knowledge or subject matter knowledge which, as we have seen, encompasses knowledge of and knowledge about subject matter of a discipline is, therefore, seen within mathematics education as crucial for teaching. The implication for teacher education and teacher trainers is thus obvious. A relevant programme for the training of school mathematics teachers should provide activities and experiences aimed at inculcating in-depth knowledge of school mathematics subject matter.

Unfortunately, however, the means for increasing appropriate subject matter knowledge is not as obvious as it might appear. General education programmes in teacher training institutions vary substantially in quality and permit students wide latitude in avoiding more demanding course work (Boyer, 1987; Galambos, Cornett, and Sopiliter, 1985). Even the requirements for a major field like English literature may vary substantially from college to college, and studies of students with extensive preparation to teach fields such as mathematics, physics, and history reveal wide gaps in their subject matter understanding of basic concepts (McDiarmid, Ball and Anderson, 1989). In defining the appropriate knowledge in the content area, several themes continue to emerge.

One issue is the relevance of the knowledge taught in academic disciplines at the college of education level to the content covered in secondary schools. Teacher education courses in English, for example, focus on literature and interpretation; language arts at the school level emphasises grammar, composition, and a full range of language-related activities, such as dramatics, speech and reading. There appear to be a similar gap between the college mathematics curriculum and what is covered in the schools. For example, the emphasis on linear algebra and differential equations may not adequately prepare students to teach arithmetic, geometry, and business mathematics as they are offered in the schools. As Hilton (1990) emphasises, "the school mathematics curriculum covers material that is dealt with nowhere else in the modern world".

Similarly in science, the specialised courses in chemistry and physics at the college level may offer inadequate preparation for teaching the more integrated courses at the school level, particularly the junior secondary school. Even if we expect school teachers to focus on the experimental logic of science in their teaching, there is little reason to expect that they directly experienced scientific investigation as student teachers at teachers colleges. Clearly, bridging this gap between the content of teacher education programmes and the content of school teaching is a significant problem.

A second issue is the way to approach the content knowledge to be learned. John Dewey (1983) once observed: "Every study or subject thus has two aspects: one for the scientist; the other for the teacher as teacher. These two aspects are in no sense opposed or conflicting. But neither are they immediately identical."

Wilson, Shulman and Richert, (1987) suggest at least two dimensions of subject matter knowledge essential for teaching: the subject content (knowledge of the facts,

organising principles, and central concepts) and the subject method of inquiry - what Morowitz (1990) terms "how we know the things we know."

The substantive knowledge of all fields is large and growing, and teachers need to comprehend the concepts and inquiry methods of a field so they can effectively make selection decisions in content. Further, teachers must be able to plan their own future learning and professional development in the content knowledge. Defining the best means to educate for this type of deep understanding remains also another critical issue.

A third issue derives from academic politics - how best to decide what knowledge in a subject field is essential for teaching? Should the decision be made by those in teacher education programmes, by those in the discipline (and by which faction within a discipline?), by teachers and policy makers in public education, or by some amalgam of all these groups? The process for defining the essential knowledge is itself unclear.

### **3.3. Pedagogical content knowledge**

However, effective teaching requires not only command of subject matter but understanding of sufficient complexity to enable the teacher to teach it. Another type of knowledge that has, thus, received major attention from researchers is knowledge of how the subject matter of a discipline should be represented in instruction. The more encompassing term of 'pedagogical content knowledge' has been applied to describe this and other types of knowledge associated with it. It first received widespread attention in 1985 when Shulman<sup>1</sup> characterised it as "the particular form of content knowledge that embodies the aspects of content most germane to its teachability". Shulman (1986) later defined pedagogical content knowledge to include,

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<sup>1</sup> Lee Shulman's 1985 presidential address to the American Educational Research Association

“...for the most regularly taught topics in one’s subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others....[Also,] an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons” (p.9)

This description rested on earlier formulations of the same idea, especially Dewey’s “psychologising” of the subject matter and Bruner’s “psychology of a subject matter”, and it quickly became the standard definition.

Researchers in this area have used Shulman’s characterisation of pedagogical content knowledge productively but have done little to clarify it. Ball (1988), for instance, began from the same basic assumption, taking “ ‘forms of representation’ ....to be the crucial substance of pedagogical content knowledge” (p. 298). She then explored the more dynamic aspects of this idea, examining pre-service teachers’ pedagogical reasoning in mathematics as the process whereby they build their knowledge of mathematics teaching and learning.

Also, Carpenter, Fennema, Peterson and Cary, (1988) and Peterson, Fennema, Carpenter and Loef (1987), investigating mathematics knowledge in first-grade teachers accepted Shulman’s definition, adding a distinction between pedagogical content knowledge and pedagogical content beliefs. Their research focused on a small number of specific knowledge measures emphasising teachers’ awareness of how their students learn mathematics. In a study of high school English teachers, Grossman (1988) developed an expanded definition of pedagogical content knowledge, based on four central components: knowledge of students’ understanding, curriculum, instructional

strategies, and purpose for teaching. With this framework she then examined the influence of teacher education on knowledge growth.

Bromme (1994) differentiated Shulman's analysis by considering "both the concept of 'philosophy of content knowledge' and a clear distinction between the knowledge of the academic discipline and that of the subject matter in school" (p.74). In so doing Bromme introduced the idea of subject-matter-specific pedagogical knowledge which, as well as Shulman's concept of pedagogical content knowledge, clearly has something to do with knowledge about how specific content can be interpreted in teaching situations. How crucial is this type of knowledge to teaching?

Pedagogical content knowledge involves taking complex subject matter and translating it into representations that can be understood by students. This translation of subject matter into understandable representations, according to Fennema and Franke (1992), "is what distinguishes a mathematics teacher from a mathematician". Wineburg and Wilson (1991), discussing history teachers, noted that the aim of a teacher is "not to create new knowledge in the discipline but to create understanding in the minds of learners". The subject matter that students are taught must, therefore be put into a framework that is understandable by the learners.

Thus, the mathematics that students are taught to do must be translated for them so that they can see the relationship between their knowledge and the new knowledge that they are to learn. Without this, the knowledge of mathematics ( or content knowledge) possessed by a teacher is of little use to him/her in the classroom situation. For example, one can have significant mathematical knowledge about the structure and property of rational numbers, but it is the ability to interpret and represent rational numbers as segments, points on a number line, parts of a whole, and parts of a set, as



well as knowledge of the role that these interpretations play in children's construction of rational numbers that are crucial.

Besides it is believed that the use of both real-world situations and concrete or pictorial representations help students learn the abstract ideas of mathematics with understanding. Thus, for teachers to facilitate learning with understanding they must know how to interpret or represent the mathematical ideas they wish students to learn. The work by Hiebert and Wearne (1986) illustrates this type of representation; It is concerned with the teaching of decimals and how Dienes base-ten blocks can facilitate learning. Also the rich knowledge base developed from research on rational numbers (e.g. Behr, Harel, Post and Lesh, 1992) is an important source of information for developing pedagogical content knowledge.

Some studies have investigated teachers' knowledge of mathematical representation and most have indicated that many teachers are lacking this kind of knowledge. For example, Ball (1988) reported on 19 pre-service teachers' abilities to develop a representation of  $1\frac{3}{4}$  divided by  $\frac{1}{2}$  and found that none of the teachers could develop an appropriate representation of the problem. Orton (1988) also investigated teachers' knowledge of representation of fraction concepts. He asked 29 in-service elementary teachers how they would teach a fraction concept to a hypothetical student who had a specific misconception about fraction. He found that most teachers relied heavily on procedural and symbolic representation rather than on a representation that would promote conceptual understanding.

Also research shows that pedagogical content knowledge is relatively undeveloped in novice teachers and that experienced teachers, too, are likely to encounter difficulty in their attempts to expand their pedagogical content knowledge base. In fact, growth in content knowledge appears to be easier for experienced teachers than growth in

pedagogical content knowledge. These patterns of findings support the recommendation that the acquisition of pedagogical content knowledge is crucial for teaching and should be a central priority in pre-service education programmes, and that it continue to receive attention in in-service programmes, available to teachers throughout their careers.

Cobb and Steffe (1983) offer a different perspective on the development of pedagogical content knowledge. Coming from a constructivist framework, they maintain that teachers' knowledge about teaching mathematics should be grounded in what we know about how children construct mathematical ideas. This knowledge is generated more from a psychological domain than a mathematical one and therefore mathematics teacher education should draw more from research on children's learning. Peterson, Fennema, Carpenter and Loef (1987) seem to accept this when they used research findings on children's knowledge about addition and subtraction and how mathematics is learned as a model against which to measure teacher pedagogical content knowledge.

There are, thus, at least two different approaches to developing teachers' pedagogical content knowledge: one that suggests that it be developed from a mathematical perspective and one rooted in educational sciences. Nevertheless, the content of both approaches is to develop the kind of flexibility in teachers' thinking that allows them to realise form in the teaching of mathematics.

In general, research emphasises the use of representation by teachers in mathematics teaching and learning; that they know the representations of the content they ordinarily teach; that they be able to apply specific methods of presentation of subject matter in a particular discipline. To be able to do this a teacher needs to know how to plan and present his/her lessons; to have knowledge of how children learn mathematics; have knowledge of various teaching methods and approaches and be able to assess and

evaluate both his/her teaching and students' learning - in other words to have what has variously been described as pedagogical content knowledge.

### **3.4. General pedagogical knowledge**

What we have described so far corresponds, to some extent, to the intuitive notion of the qualities required of a good teacher: the teacher has to have something which (s)he would teach and (s)he has to know how to teach it. Traditionally, his/her course in what was referred to as teacher training college (TTC) was polarised into 'teaching subjects' and 'methods'. However, as was pointed out earlier, recent thinking has recognised that the professional knowledge required of a teacher is more complex than this. Method, for instance, is not just the acquisition of a collection of different approaches to be applied universally, when teaching a topic or concept, irrespective of the nature of the pupils being taught, nor does it correspond entirely to what we have described, in the preceding sections, as pedagogical content knowledge.

Researchers (e.g. Shulman, 1986; Fennema & Franke, 1992; Ball, 1990a; Bromme, 1994; Harel, 1994; Cooney, 1994, Lappan and Theule-Lubienski, 1994 etc.) have recognised this by subdividing teacher professional knowledge into two strands: pedagogical knowledge/skill specific to the subject matter of a discipline and pedagogical knowledge pertaining to the teaching profession in general. The former is what we have described and contextualised previously as pedagogical content knowledge. The latter includes knowledge of epistemology and those broad principles and strategies of classroom management and organisation that appear to transcend subject matter (e.g., curriculum studies, psychology, educational technology and educational foundations, etc.). Recognising that teachers can no longer apply a set of

skills like unthinking machines, colleges have also reflected this in their courses and have changed their names to colleges of education, thereby removing the stigma associated with 'training'.

Another component of the complex knowledge structure of teachers that has, therefore, received attention from research is teachers' general knowledge of their students, the learning process, the teaching profession and teachers' role in society. Various terms have been applied to describe this type of knowledge and different authors have included different skills and knowledge in it. Shulman, for instance, described it as general pedagogical knowledge. Ferguson and Womack (1993), and a host of others, prefer to use the term "educational course-work" to include this and all but subject matter courses in a college of education. Harel (1994) includes in it knowledge of epistemology. Teachers, according to Harel, must understand fundamental psychological principles of learning:

"that students construct their own meaning as a result of disequilibrium while they encounter new knowledge, that the source of any knowledge construction is an experiential problem solving activity and that mathematics is a social construct students establish through a negotiation process". (pp 113-119)

There existed some controversy over the relative importance of this type of knowledge in teacher preparation. For example, in *A Nation at Risk*, (NCEE, 1983) the authors contended that teacher preparation programmes are too heavily weighted with "courses in educational methods at the expense of courses in subjects to be taught". Subsequent reform documents, especially in the US (e.g. Holmes Group, 1986; Carnegie Forum on Education and Economy, 1986; Murphy, 1990; Sikula, 1990) also expressed this view. On the other hand, teacher educators argued, on the basis of conviction rather than

hard evidence, that extensive pedagogical training is essential in the preparation of effective teachers.

A considerable body of research, however, exists which confirms that general pedagogical knowledge has a positive effect on teaching performance (Darling-Hammond, 1991; Ashton and Crocker, 1987; Evertson, Hawley and Zlotnik, 1985). Ashton and Crocker (1987), for instance, report that a positive relationship has been found between the amount of education course-work taken by teachers and their students' achievement, implying at least a moderate benefit from credits earned in professional education courses. Another group of studies ( e.g. Denton and Lacina, 1984; Grossman, 1990) demonstrated that teachers who were graduates of teacher education programmes received higher ratings than non-education graduates on their performance in the classroom. The abilities assessed were their ability to introduce and conclude lessons, communicate effectively with students, and relate content to the students' needs and interests.

A large scale study by Kennedy (1991) of teacher education programmes conducted with more than 700 teachers and teacher candidates revealed that majoring in academic subject provided no assurance that teachers were prepared to be effective classroom instructors. Druva and Anderson (1983) in their meta-analysis of 65 studies on the effects of subject matter and education preparation on teaching of science teachers concluded that both education and science courses are positively associated with successful teaching. And research shows that teachers who entered the classroom through alternate quick-entry routes had greater difficulty than graduates of traditional programmes in attending to students' motivation, differing learning abilities, curriculum development, classroom management, and determining appropriate teaching methods (Darling-Hammond, 1991; Grossman, 1989).

Evertson, Hawley and Zlotnik's (1985) review of studies comparing the instructional behaviours and the achievement of students of provisionally versus fully certified teachers revealed that regularly certified teachers performed more effectively than teachers with less formal training. Preparation in professional education has also been found to be positively associated with increased teacher sensitivity, effectiveness in dealing with diverse student needs and the ability to teach in a style that facilitates higher order learning (Ashton and Crocker, 1987). The effect of education course-work is particularly noticeable when achievement is measured on higher-order tasks such as students' ability to apply and interpret concepts.

With reference to the progressive impact of general pedagogical knowledge, Skipper and Quantz, (1987) found that as students passed through their professional education courses they become increasingly student centred in their attitudes and more knowledgeable about methods which are consistent with student development and critical thinking. Studies have also shown that teachers without knowledge of classroom management skills, for instance, have more difficulties managing routine tasks than teachers with training in these skills. Thus, existing research strongly suggests that general pedagogical knowledge or education course-work makes a difference in teaching performance. The implication for teacher trainers is obvious. A suitable or relevant teacher education programme must provide for, not only pedagogical knowledge specific to the particular subject matter to be taught but, general pedagogical knowledge: that is knowledge that pertains to the teaching profession in general. This includes knowledge of the theory of education, philosophy of education, history of education, psychology of education, child development, curriculum studies, and management skills.

### 3.5. Context knowledge

Survey studies (for example Cockcroft, 1986) as well as analyses of children's knowledge of mathematics (for example, Carraher, Carraher, & Schliemann, 1985, 1987; Ginsburg, 1977; Ginsburg, Posner, & Russell, 1981; Hughes, 1986; Resnick, 1984) have shown that much mathematical knowledge is acquired outside school. Also, D'Ambrosio (1984, 1985) showed that much of what is learnt outside school is influenced by the culture of the immediate society. He used the expression "ethno-mathematics" to refer to the forms of mathematics that are embedded in cultural activities. For example, everyday activities such as building houses, exchanging money, weighing products, and calculating proportions for a recipe. These are applications of mathematics which, though they often look different from those used in school, involve numbers, calculations and, sometimes, precise geometrical patterns. They vary significantly across countries, because of the differences in the numeration systems used, for example, or the devices used for calculation. These differences may be perceived as deep- or surface-structure differences, depending on what views one holds of mathematical knowledge. Nevertheless their existence highlights the need for different approaches (and perhaps different contents) in mathematics teaching in differing situations.

Also, modern social sciences like psychology and sociology have shown that individuals differ and so do cultures and subcultures. Besides, recent thinking about the qualities required of a teacher has shown that there is a strong link between the work of a teacher and that of other social workers and even personnel managers in industry. Thus, teachers' role, conceived in modern terms, requires a diversity of skills, knowledge and personality.

For instance, it has been known for years that teachers are concerned in part with the socialisation of the child, although this awareness has not always been reflected in teacher education programmes. In a society like that of Nigeria which is in a state of flux and also essentially pluralistic there is great need for teachers to involve themselves in the socialisation process even more than the parents. This need is made greater by the realisation that modern Nigerian parents tend to abrogate some of their own responsibilities in this area, and that many Nigerian secondary schools are residential (boarding) establishments.

Craft (1971), develops an inter-professional thesis that there is both a mental health process in teaching and also a social process. And quoting Tibble (1959) as follows:

(Teachers and social workers)....." are essentially engaged in bringing about changes of one kind or the other in people, adults or children, who are by definition in a state of need; either because of their immaturity and dependence as children or because of some maladjustment between person and environment." (Tibble, 1959)

he argues that there are several continua which link the roles of teacher and social worker and, thus, that there are good reasons to support the idea of their being educated in a more closely integrated system. While the health visitors, community health officers, industrial personnel officers and other professions, that are traditionally described as social workers, are more concerned with using education as a means of social control to alleviate the maladies of society, teachers are, on the other hand, concerned with socialisation understood in terms of enabling the pupil to be apprenticed to the norms of his own culture.

These differences in function, he pointed out (and I think rightly), could be seen as differences in degree along the various continua and, therefore, that teachers and social workers could benefit from the mutual interaction of being educated side by side in the



same institution; an institution which would clearly have much broader function than that of the present colleges of education.

Although Nigeria is yet to develop her social services, we are here concerned with the long-term development of the system for teacher education. It seems pertinent, then, to raise the possibility of a much broader-based college as the ultimate objective of the training process we are concerned with in this study.

As is acknowledged, the teacher's role, conceived in modern terms, requires a diversity of skills and knowledge; a college of education should, in the words of Chambers,

“...challenge a student, further his personal education and give him insights into his own development ... and equip him with skills, information and focused attitudes to children, school and society.”  
(Chambers, 1971, p.71)

The realisation that mathematical knowledge can be acquired outside school, that cultural influences on mathematical activities are important to mathematics learning and that the teacher has a social role to play, bring new variables into mathematics teaching and learning. For instance, is the mathematics learned outside school the same as that taught in school? How can teachers identify and capitalise on mathematics learned outside school? And of more importance to teacher trainers is the question of the type of activities to be included in programmes for teacher education in order to inculcate the ability to identify and use mathematics that are embedded in cultural activities for the benefit of their (i.e. the teachers') pupils.

One further component of teacher knowledge that has, therefore, received attention is knowledge of the environment/society in which school is situated or the context in which teaching is to take place. Different people have used different expressions to describe this type of knowledge, for example, “situation knowledge” or “knowledge of society” and

so on. Grossman (1990), however, used the term 'knowledge of context' and described it as,

“...knowledge of the districts in which teachers work, including the opportunities, expectations, and constraints posed by the districts; knowledge of the school setting, including the school “culture”, departmental guideline, and other contextual factors at the school level that affect instruction; and knowledge of specific students and communities, and the students’ backgrounds, families, particular strengths, weaknesses, and interests” (p.9)

In this study, we used the expression “context knowledge” to represent it and defined it as the character and culture of the community for which the trainee is destined; including, apart from those components identified by Grossman, the needs, vocations, aspirations and expectations of the community, district or school; the purpose of education as envisaged by the community, the history, beliefs and religion of the community; knowledge of how school is financed and administered in the particular society. This aspect of teacher knowledge is very important in the Nigerian context because social and cultural values in the country are varied, complex and delicate; especially in view of the disparities in education between the northern and southern parts of the country and between the highly urbanised areas and the less urbanised ones. Besides, over 75% of school teachers in the north come from the south.

As in most developing countries, a relatively small section of the population - urbanised, to a large degree westernised in life style and employed in the ‘modern’ industrial and administrative sector - exists as a definable stratum above that mass of rural-dwelling, agriculturally based, traditionally minded farmers, nomads and peasants. Cutting across this basically economic division are social and religious divisions discernible along ethnic and geographical lines. To the north of the Niger and Benue rivers approximately half the population accept a feudalistic, hierarchical system, deriving from earlier kingdoms whose driving and unifying force was, and still remains, Islam. In the south

both the Ibo and Yoruba, together with their subgroups, adhere, again largely on traditional lines, to a more dynamic, fluid, entrepreneurial and socially mobile society than obtains in the north. This has meant that the north has continued to lag behind in education. Despite the manifest differences, however, the south shares with the north a pattern of strong traditional authority.

Linguistically, Nigeria is extremely diverse, a recent survey<sup>2</sup> having isolated 400 languages. Of these, three major languages - Hausa, Igbo and Yoruba - are spoken by approximately half the population although not necessarily as a mother tongue. National radio broadcasts are put out in all of these major languages as well as in Efik, Edo, Kanuri, Tiv, Fula, Ijo and English. It has been estimated that 15% of the population can speak English, although only a small proportion are fully literate in standard English, the others being users of Pidgin varieties. Pidgin is used in multi-lingual areas, especially in large towns and the "foreigners' quarters" of the north. Arabic, the sacred language of millions of Muslims, is used comparatively little as a contact language. Although there is no official national language, all important announcements and documents are produced in English, which can therefore be regarded as both the official language and the lingua franca.

The implication to mathematics teacher education in Nigeria is the influence exerted on school and college curricular by demands of these social and cultural differences. For instance, in the north the Islamic influence decidedly makes the teaching of the concept, such as probability, particularly difficult; since the religion teaches that any pretence to be able to predict the future by any means is blasphemy. Another example is the concept of banking and interest earned as a result of investing a capital sum in a bank. Muslims are by faith forbidden to accept interests for money invested in any bank and

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<sup>2</sup> Federal Government of Nigeria (1994), *Survey of Participants in National Youths Corp. Exercise for 1993/94 Year*. Published by FGN in August 1994

therefore many refuse to participate in any discussion on the concept of simple or compound interest, which they see as unethical. Examples such as these abound. The topics/concepts appear in the school mathematics syllabus which are examined by WAEC for the SSC and, therefore, have to be taught and learned if success in the SSC is envisaged. A prospective mathematics teacher destined for northern Nigeria should, therefore, be given the opportunity, through training, to be aware of the existence of these peculiarities and perhaps taught ways of presenting them that do not offend or estrange his pupils.

A further example, of cultural variation in Nigeria that is, perhaps, useful to cite here is the numeration systems of the two major ethnic groups in the south of the country: the Yorubas and Ibos. The Ibos count in "bundles of ten" - *iri* - and "bundles of twenties" - *nnus* - adding or subtracting numbers up to nine. The Yorubas, on the other hand, use a system which alternate between addition and subtraction depending on how large the number is. For example, the Ibo would say "two-bundles of twenty without nine" and "two bundles of twenty without one " for the numbers 49 and 39 respectively, while the Yoruba would say "fifty without one" for the number 49 but "thirty with nine" for the number 39.

The designers of the national mathematics curriculum for Nigerian schools seemed to have taken these cultural variations into consideration when they included topics such as "An indigenous system (*of numeration*) of special relevance locally" and recommended that pupils be encouraged to investigate "local counting and reckoning systems including writing of essays and reports". (FME, 1982, revised 1990). The implication to teacher trainers is obvious. To be relevant in the Nigerian context, a programme for the education of mathematics teachers must provide for, not only knowledge specific to the mathematics to be taught or knowledge pertaining to

educational principles and practices, but also knowledge about the culture and values of the particular locality in Nigeria in which the student teachers are to teach. Teachers must be aware of the particular context in which they teach and must be able to draw upon their understanding of that particular context to adapt their more general knowledge to specific school settings and individual student. To be of use for classroom practice, a teacher's knowledge must be context-specific (Lampert, 1985).

### **3.6. Practical skill**

Finally, from what has been said in the preceding sections, it is clear that the education of teachers is not a purely academic enterprise; it also requires the learning of professional skills and techniques. Teaching is, thus undeniably, a practical activity and, as such, requires that its practitioners develop practical skills in addition to theoretical insights. Colleges of education are, very much like the universities, concerned with the life of the intellect and with building a community of students mutually engaged in the task of pursuing truth. Their orientation is, therefore, usually academic and theoretical and not necessarily practical. Educators have realised this fact for many generations and have, therefore, included a period of practical teaching in teacher education programmes. More recently, initial teacher education have become more practical and school based. There is disagreement, among educators in various countries, on the structure and duration of activities for inculcating the practical skill (see for example Young, 1994; Lawlor, 1990); what is, however, never in dispute is the need for such activities.

### 3.7. Nigerian government policy on teacher education

Published by the government in 1977, the National Policy on Education (NPE) appears to have the authority of only a White Paper, but its recommendations are being implemented both nationally and in the states. The policy it puts forward is in no way revolutionary and confirms the tendencies which have existed since the seminar on 'National policy on Education' in 1973. The government makes clear that it regards education as an instrument *par excellence* for effecting national development and that it is for the government to spell out educational policy and to develop a uniform national system. The recommendations, as they pertain to teacher education are as follows:

"Grade II is to be the lowest teaching qualification and all teachers practising at present must achieve this through in-service training. The Nigerian Certificate in Education will eventually be the basic qualification for all future teachers. In-service training will be systematically planned and teachers will earn credits for increments or promotion. Teaching is to be legally and publicly recognised as a profession. NCE holders will be enabled to complete a university degree in two years"

(FME, 1977, 1981)

And, in the preamble of the 1981 revised edition it states that:

"...the curriculum of teachers' colleges will consist of:

- (a) General studies (courses essential to Nigeria)
- (b) Foundation studies (principles and practice of education);
- (c) Studies related to the student's intended field of teaching.....and
- (d) Teaching Practice".

(FME, 1981)

The National Commission for Colleges of Education (NCCE), a body charged with regulating the activities of colleges of education in Nigeria, attempted to clarify this in 1990 through its Guideline on Minimum Standards (NCCE, 1990) by detailing examples of course titles that, it thought, fit within each of the four headings listed in the National Policy. This is shown in Table 3.1 together with the six components of teachers knowledge identified by research and the Nigerian government national policy recommendations.

Table 3.1. KNOWLEDGE COMPONENTS OF A TEACHER EDUCATION PROGRAMME

Theoretical Components	Indigenous components	
	Nigerian National Policy	NCCE
Content Knowledge (i.e. knowledge of subject matter and knowledge about subject matter)	Specialist Subjects	It gives a list of 49 choices which included mathematics. (Although not made explicit it is assumed that this includes methods and representations of subject matter)
Pedagogical Content Knowledge		
General Pedagogical knowledge	Foundations	Theory, principles and practice of education Philosophy of education Psychology of education History of education
Context Knowledge	General Studies	Use of English Philosophy and logic History and philosophy of science Nigerian peoples and culture
Practical Skill	Teaching Practice	Practical assignment equivalent to at least 12 weeks teaching assignment in a secondary school

From this table it is seen that 'general studies' as described in the policy could be taken to correspond to what we have contextualised in this study as context knowledge. Foundation studies corresponds to general pedagogical knowledge. Specialist subjects are studies related to the student's intended field of study (e.g. mathematics) and could be described as consisting of subject matter knowledge and pedagogical content knowledge. The implication of these to us in this study is the recognition that an optimum educational programme for the education of mathematics teachers, especially a programme that is to do the best job in the Nigerian context, must provide activities

that will enable trainees to acquire or develop the six components of teachers' knowledge which is identified by research as essential for the craft of teaching.

However, the general issue relating to all the various knowledge components that we have considered to be important in the education of teachers, are the question of how we can justify their inclusion in the curriculum; how we can treat them in relation to one another; what should be the appropriate time application or effort between them and what do they look like in practice. That is what does a student do and what does a teacher trainer do, etc.? It is most likely that the practice in relation to these components in teacher education varies significantly between countries, colleges and even with specific type of teacher education programmes. These are in fact the key issues that need to be addressed in relation to the education of teachers of mathematics.

Besides, as noted by Kennedy (1986), teacher education programmes are not variables that can be manipulated in any simple way. They are formed by governments (state and federal in the case of Nigeria), student bodies, and demands of client school proprietors. Similarly, what students learn about teaching while participating in these programmes depends on what they already learned elsewhere, on their ability to learn, on their beliefs about teaching, on their dispositions towards teaching, on their inclination to learn, and on their concurrent learning experiences. We cannot control all of these influences; indeed we cannot even measure all of them. In fact, fundamental concerns have been raised regarding what one can expect teachers to learn about teaching during a few semesters of college - relative to what they have learned about teaching throughout their lifetime and what they will learn about teaching on the job.

Prospective teachers have had an average of fifteen years of schooling before they take a formal course in teacher education. After leaving teacher education programmes



students are exposed to immediate pressures (for example, career evaluation systems) and to continuing internal (career ladder) and external constraints (education laws, the media). These forces interact in complex ways with a given teacher's training, ability, and philosophy so that it is hard to conceptualise linkages between teacher education and classroom practices.

Besides, various experiences combine to influence actual teaching behaviour. For example, in Nigeria, mathematics educators may find that their call for more emphasis on problem solving, estimation, and measurement in primary school instruction may be neutralised by a local government's implementation of a new mathematics testing programme that emphasises computation and basic concepts. The testing programme may be implemented because of the philosophy of local government administrators, but it may be fuelled because of external pressures (newspaper articles, influential citizens). However, independent of the antecedent that led to the development of the testing programme, its presence will affect how much instruction is offered in various mathematical topics and so on.

In Nigeria, as indeed in UK and many other countries, these are issues that plague the teacher education process: the issue of relevance of the subject matter of a teacher education programme to the subject matter of a discipline in a school; how to bridge the gap (if any); how to select the content knowledge of teacher education, how to make sense of the diverse approaches to teacher education adopted by different colleges of education in the country and so on. Abatan (1993) pointed out that "There is hardly any research in Nigeria concerning the education of secondary school mathematics teachers" (p. 221). There is, therefore, a great need for studies which will look at least at one of these issues in teacher education in the Nigerian context. The present study was consequently embarked upon in order to provide the impetus and depth of

understanding that will guide reform initiatives on mathematics teacher education in that country.

### 3.8. Summary

To summarise a number of notions of teacher knowledge have been generated by research that have tried to describe and delineate the knowledge base for teaching. But, while researchers differ in their definitions of the various components, extensive evidence indicates that teaching is best understood as an active practice in which the teacher constantly makes decisions. The knowledge essential for this kind of thought and role can be classified into two groups: subject matter (or content) knowledge and pedagogical knowledge. These two, as well as one other, practical experience, which although classified by various writers as a sub-component of the latter, are seen as the pivots upon which successful teaching hinges.

The former consists of knowledge *of* subject matter (e.g. core topics/concepts, procedures and relationships among them and how to present them) of a particular discipline (e.g. mathematics) and knowledge *about* subject matter (e.g. history, purpose and nature of mathematics). There is, in this case, a widely recognised need for agreed guidelines on the content of training to reflect the need of school mathematics in a particular context and for a guarantee of an acceptable level of preparation in the subject or aspect of the curriculum which a teacher offers to teacher. The choice of what is relevant content is, however, dependent on where and for what purpose the training is intended.

The latter (a more complex component) presents difficulty because teacher educators, and indeed the wider society, disagree on what should or should not constitute pedagogical skills or the terminology used to describe its various sub-components or its

relative effect on teacher performance. However, three sub-components - general pedagogical knowledge, pedagogical content knowledge and knowledge of the environment/society in which the teaching is taking place - are generally recognised, by various authors, as the cornerstones of the emerging work on professional knowledge for teaching. For want of a better term, it was decided to, henceforth, refer to the last of these three sub-components as "context knowledge" in this study. Practical skill, which could be regarded as the vocational strand of the professional knowledge, is experience acquired through teaching, during training, in a secondary school or through one of the more modern models of training, for example school-based model, micro-teaching, peer-group teaching, etc. Figure 3.2 summarises the essential features of the conceptualisation discussed in this chapter.

Figure 3.2 ESSENTIAL FEATURES OF A MATHEMATICS TEACHER EDUCATION PROGRAMME

CONTENT KNOWLEDGE	PEDAGOGICAL KNOWLEDGE	CONTEXT KNOWLEDGE	PRACTICAL SKILL
<p><b>1. Knowledge of subject matter</b> (core topics, concepts, or principles; procedures and relationships among topics, concepts or principles)</p> <p><b>2. Knowledge about subject matter</b> (e.g. history, purpose, and nature of mathematics, belief about mathematics, etc.)</p>	<p><b>3. General pedagogical Knowledge.</b> -Theory of education -Learning theories -Psychological principles about learning (e.g. Human Development, etc.) -Philosophical theories about education. -Curriculum studies -History of education -Skills of management etc.</p> <p><b>4. Pedagogical Content Knowledge</b> -Lesson planning in maths. -Lesson presentation in maths. -Methods of teaching specific topics/ concepts in maths. -Teaching methods and approaches -Theories of maths learning -Assessment/evaluation skills in math., etc.</p>	<p><b>5. Context Knowledge:</b> -Working of the group/class -Governance of school -Financing of school -Character and culture of the community in which the school situates. etc.</p>	<p><b>6. Practical Experience</b> gained during teaching practice in the form of any one or all of the following:-</p> <p>-Traditional teaching practice. -Micro-teaching -School-based training model. -Peer -group teaching -etc.</p>

## CHAPTER 4

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### RESEARCH DESIGN AND METHODOLOGY

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#### 4.1. Introduction:

The literature review presented in the preceding chapter, provided the background understanding and the theoretical framework upon which this study is modelled; in the choice of strategy, the design of the tools for data collection, and in the determination of the procedure to be adopted for data analysis. However, certain state of affairs in Nigeria also influenced the decisions about the sampling procedure adopted and the data collection exercise; affecting particularly the size of the sample and the timing for the administration of one of the research instruments used. It is necessary, therefore, to begin this chapter with a brief account of the context under which the study was carried out.

Between January 1992 and October 1994 there were a series of interruptions in the research, due to some political unrest in Nigeria, in the educational system and civil service of the country. All universities in Nigeria were shut down from January 1992 to the end of June 1992 because students were protesting against the military government which sought to extend its rule beyond 1992. In July 1992, all higher institutions (universities, colleges and polytechnics) were again closed because lecturers embarked on a national strike. They were protesting against the prevailing poor learning conditions as well as the unfavourable conditions of service in the universities and other institutions of higher learning in the country. The strike was called off in October 1992.

Barely a month after the lecturers' strike, primary and secondary school teachers went on strike in November 1992. They were also demanding improvement, similar to that agreed for higher education institutions, in their conditions of service. The whole of 1993 and part of 1994 saw series of upheavals and disruptions in the day to day life of all Nigerians. There was the petrol/fuel shortage which paralysed the transport system for nearly two years; there was the acute shortage of car and motor parts which meant that even if one was to find the fuel there were no cars to use it in; there were the postal strike, electricity workers strike and so on. The climax came in November 1993, when the country's entire civil service, banks, custom officers, and immigration officers joined secondary and primary school teachers in demanding a review of their salaries. This continued until October 1994 when the researcher left Nigeria for UK.

During this period (January 1992 -October 1994) educational services suffered a great deal. Work in the country was generally paralysed both in the offices and schools and travel and communication were seriously hampered.

It was in the midst of all these confusions that decisions about sampling procedure, sample size and the design presented in this chapter were made. Although colleges of education were in session during the period May 1994 to September 1994, when the actual fieldwork for this study was undertaken, the situation in the country was taken into consideration in its design. Consideration about the feasibility of successfully accessing the sampled colleges, meeting student teachers and executing a chosen design, given the context described above, was a dominant factor.

The study set out to determine:

- a) the characteristic features of programmes that exist in Nigeria for the initial training of school mathematics teachers;
- b) the differences among the training programmes;

- c) the relationship between training curricula and school mathematics curriculum in Nigeria;
- d) the level of understanding of school mathematics subject matter among trainees who have completed the training programmes.

The specific questions addressed in the study were:

- 1) What conditions or programmes exist for the training of school mathematics teachers in Nigeria?
- 2) In what respect do school mathematics teachers training programmes in Nigeria differ among themselves? In other words, if they differ how are they different?
- 3) In Nigeria, is there any relationship between the mathematics teacher training curricula and the school mathematics curriculum for which teachers are being prepared to implement?
- 4) What level of understanding of school mathematics subject matter in Nigeria do student teachers possess at the terminal point of training as their basis for teaching the NNMC?
- 5) Are there any differences between programmes in the level of subject matter understanding of student teachers passing out from different colleges of education in Nigeria?
- 6) In Nigeria, is there any relationship between curricular provisions for the training of school mathematics teachers and the needs of the trainees?

This chapter describes the research design, (much influenced by the situation described earlier) which was planned and carried out in order to provide data to help in answering these questions. It tells the story of the efforts made to ensure that the research population is reflected in the sample. It describes the instruments employed to collect

data for the study and presents some justification for the statistical procedures adopted in analysing the data.

#### **4.2. The population**

The research population was made up of mathematics programmes for initial training of teachers, student teachers in full-time attendance in colleges of education where the Nigerian Certificate in Education (NCE) programme is being run for mathematics teachers, and teacher trainers at various colleges of education. Initially a list was provided by the Federal Department of Statistics (FDS) of addresses and locations of educational institutions offering the NCE mathematics programme. Additional data were obtained from the Federal Ministry of Education (FME) and the Nigerian Education Research Council (NERC). During a follow up contact it became apparent that the list and data were out of date. Although institutions no longer offering NCE courses could be removed, additions could not be made for new colleges and institutions omitted from the lists and data provided.

However, in the course of this preliminary search it was realised that, as a result of the affiliation scheme ordered by the federal government in 1976, every institution in Nigeria offering the NCE programme was affiliated to one university in the country. It was, therefore, possible to obtain a complete list of these institutions from the Institutes of Education of the universities. The distribution of NCE mathematics teacher training colleges of education according to the university to which they were affiliated is shown in Tables 4.1.



Table 4.1. UNIVERSITIES AND THEIR AFFILIATED COLLEGES OF EDUCATION

UNIVERSITY	CODE <sup>1</sup>	AFFILIATE COLLEGES	TOTAL
1. Obafemi Awolowo University, Ile-Ife	OAU	1. Adeyemi College of Education 2. College of Education, Ijebu-Ode 3. College of Education, Ikare-Ekiti	3
2. University of Ibadan, Ibadan	IBADAN	4. College of Education, Oyo 5. Federal College of Ed.(Sp), Abeokuta 6. College of Education, Ilesha 7. College of Education, Ila-Orangun	4
3. University of Ilorin, Ilorin	ILORIN	8. Federal College of Education, Okene 9. College of Education, Ilorin 10. College of Education, Oro	3
4. Unive Lagos	UNILAG	11. Federal college of Education, Akoka 12. College of Education, Ijaniki	2
5. Unive Nsukka	UNN	13. Federal College of education, Umunze 14. College of Education, Awka 15. College of Education, Nsugbe 16. College of Education, Eha-Amufu 17. Alvia Ikoku Coll. of Ed. Owerri 18. College of Education, Enugu	6
6. Ahmadu Bello Unive Zaria	ABU	19. College of Education, Kano 20. College of Education, Zaria 21. College of Education, Azare 22. College of Education, Ankpa 23. College of Education, Kafanchan 24. College of Education, Mina 25. College of Education, Gindiri 26. Federal College of Education, Katsina 27. Federal College of Education, Kontagora 28. Federal College of Education, Bichi 29. Federal College of Education, Gombe 30. Federal College of Education, Potiskum 31. Federal College of Education, Gusau 32. Federal College of Education, Obudu	14
7. Unive Jos	UNIJOS	33. Federal College of Education, Pankshin 34. College of Education, Katsina-Ala 35. College of Education, Akwanga 36. College of Education, Hong	4
8. Unive Maiduguri	UMAID	37. Federal College of Education, Yola 38. College of Education, Maiduguri 39. College of Education, Waka-Bui 40. College of Education, Gasua 41. College of Education, Bama 42. College of Education, Jalingo	6

<sup>1</sup> University Identification ID codes used here are those published by the Joint Admissions and Matriculation Board (JAMB) in its Brochure for 1991/92 academic session. Subsequent reference to these universities in this study will use these ID codes.

9. Bayero University, Kano	BUK	43. College of Education, Gumel	1
10. Usm Univ	UDU	44. College of Education, Sokoto	1
11. Univ Benir	UNIBEN	45. College of Education, Asaba 46. College of Education, Eki-Adolor 47. College of Education, Agbor 48. College of Education, Warri	4
12. Univ Harc	UPOINT	49. College of Education, Omoku 50. College of Education, Afaha-Nsit 51. College of Education, Akamkpa 52. Federal College of Education, Uyo 53. College of Education, Port-Harcourt	5

#### 4.3. The sample

In choosing the research sample and determining the manner in which the sample was drawn, three factors were influential. The first was that the institution must have been running the NCE mathematics training programme for at least three consecutive years. This is the minimum duration for training as a teacher in Nigeria. The second was limited finance because of the economic crisis and social unrest in the country at the time. The study was entirely financed by the researcher. The third was considerations of accessibility. Transportation which at normal times is very expensive in Nigeria barely existed after 1992.

At the time when the fieldwork for this study was carried out in 1994, all the fifty-three (53) colleges of education in Nigeria had been running NCE mathematics programmes for at least three years.

The original idea was to collect and examine, one by one, all mathematics teachers training programmes from the 53 colleges of education in Nigeria; interview as many teacher trainers (especially the heads of mathematics departments) and student teachers in each institution as possible about their training programmes. But because

of the cost and the physical and transportation difficulties, which would have been involved in attempting such a nation-wide survey, this idea had to be dropped.

The selection of a sample of colleges from which training programmes would be analysed was thus made by a method similar to that of stratified random sampling. First, the colleges of education were sorted into groups according to the universities to which each was affiliated. This decision was based on the assumption that a group of colleges, affiliated to the same university, operated the same or similar training programmes. This was because, in compliance with the NCCE's Policy Document on Minimum Standard (NCCE,1991), colleges of education were obliged to adopt programmes recommended to them by their respective validating universities. This assumption was later tested and confirmed to be true by collecting and comparing three programmes from three different colleges in university affiliation group 6 (ABU) and two from group 5.

Second, from each group of colleges, one college of education was selected at random and, provided that it was easily accessible, it was included in the sample. If a selected college is not easily accessible another college was randomly selected to replace it. It is realised that this could affect the representativeness of the sample but this is the best possible option in the face of the difficulties and constraints imposed on the researcher by the situation in Nigeria described earlier. Twelve training programmes were selected for analysis through this process.

The selection of student teachers and teacher trainers was based on the original list of 53 colleges. From each programme group, final year students teachers were selected at random in proportion to the number of colleges in the group. Lists of final year mathematics student teachers were obtained, where possible, either direct from the colleges of education or from the university of affiliation. Five student teachers were

then selected at random from each of the lists. These were then invited to participate in the research. This procedure was used to select student teachers in 47 out of the 53 colleges of education in the country.

For the remaining 6 colleges, where for very good reasons this was not possible, the heads of mathematics department or their deputy was asked to send the names of five of their student teachers to the researcher. The effect of this dependence on the ability of these individuals to sample randomly (and other limitations) on the composition of the sample is discussed later.

Also, one teacher trainer was selected at random from each college of education. To control for experience, only trainers with at least five years of teaching experience were selected. As for qualifications, only teacher trainers with qualifications in mathematics education or in mathematics were selected.

This procedure ensured that the samples were representative of the population from which they were drawn. For although there are thirty-two (32) universities in Nigeria, only twelve (12) have colleges of education affiliated to them (Table 4.1). And since each validating university does prescribe training programmes to their affiliate colleges, it was, as said earlier, reasoned that a group of colleges affiliated to the same university is likely to be using similar, if not the same, training programme. In fact three programmes from each of the two largest programme groups (Groups 5 and 6) were found on comparison to justify this assumption. The 12 sample programmes were, thus, selected, so that each of the twelve groups of colleges of education shown in Table 4.1 was represented. The sample was, therefore, typical of all programmes in the 53 colleges all over the country and was a fair representation of them.

Also colleges of education in Nigeria, for reasons (economic and political), affiliate to universities near to them (NCCE, 1994). So that, in effect, the two traditional divisions

(north and south), in terms of educational provision and attainment, of the country are represented in the twelve programmes groups and hence within the twelve sample programmes selected for analysis.

The sample of student teachers was drawn randomly from all the 53 colleges of education in the country; the sample is, therefore, a fair representation of the population of all final year mathematics student teachers in all colleges of education in the country at the time the field exercise was carried out.

The research samples are, therefore, as follows:-

- Twelve (12) NCE mathematics teacher *training programmes*;
- Fifty-three (53) *teacher trainers* (i.e. mathematics/mathematics education lecturers in colleges of education in Nigeria).
- Two-hundred and sixty-five (265) final year NCE mathematics *student teachers* from colleges of education in Nigeria.

Table 4.2. shows the distribution of sampled programmes according to the status<sup>2</sup> and location of colleges, in the two geographical divisions of north and south from which the samples programmes were collected. Table 4.3 shows the distribution of the 265 student teachers according to programme groups and some initial entry variables.

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<sup>2</sup> **Status:** of colleges of education in Nigeria are determined based on whether they are owned by a state government or the Federal government. Private ownership of higher institutions in Nigeria was outlawed in 1990. Established private colleges (e.g. The Ecumenical College at Enugu owned by the Catholic Church) were either closed or taken over compulsorily by the state/federal government in 1990.

TABLE 4.2 DISTRIBUTION OF SAMPLE PROGRAMMES

PROG	UNIVERSITY CODE	COLLEGE FROM WHICH SAMPLE PROGRAMME WAS COLLECTED	GEOG. LOCATION	STATUS
A.	OAU	Adeyemi College of Education	South	State govt.
B	IBADAN	College of Education, Oyo	South	State govt
C	ILORIN	Federal College of Educ., Okene	North	Fed. govt
D	UNILAG	Federal College of Educ., Akoka	South	Fed. govt
E	UNN	College of Education, Awka	South	State govt
F.	ABU	College of Education, Azare	North	State govt
G	UNI JOS	Fed. College of Educ., Pankshin	North	Fed. govt
H	UMAID	College of Education, Jalingo	North	State govt
I	BUK	College of Education, Gumel	North	State govt
J	UDU	College of Education, Sokoto	North	State govt
K	UNIBEN	College of Education, Eki-Adolor	South	State govt
L	UPOINT	Federal College of Educ., Uyo	South	Fed. govt

TABLE 4.3. DISTRIBUTION OF STUDENT TEACHERS

PROG	SEX		AGE		INITIAL ENTRY QUALIFICATION		TOTAL
	MALE	FEMALE	<=25	>25	GCE <sup>3</sup>	TC2 <sup>4</sup>	N =
A	5	10	7	8	7	8	15
B	12	8	14	6	11	9	20
C	12	3	5	10	8	7	15
D	10	0	7	3	6	4	10
E	23	7	20	10	17	13	30
F	52	18	39	31	30	40	70
G	17	3	10	10	8	12	20
H	29	1	13	17	9	21	30
I	5	0	3	2	3	2	5
J	5	0	3	2	2	3	5
K	13	7	12	8	9	11	20
L	19	6	17	8	15	10	25
<b>TOTALS</b>	<b>202</b>	<b>63</b>	<b>150</b>	<b>115</b>	<b>125</b>	<b>140</b>	<b>265</b>
	<b>76%</b>	<b>24%</b>	<b>57%</b>	<b>43%</b>	<b>47%</b>	<b>53%</b>	<b>100%</b>

#### 4.4. Methods of data collection

Three different instruments were used to gather the data for this study: a school mathematics contents test (SMCT), a questionnaire and a content check-list. The use of more than one type of data gathering instruments in a single study is not unusual (see

<sup>3</sup> Student teachers who had credit in mathematics at GCE 'O' level or the WASC or the SSC but without any teaching qualification before they entered colleges to train as mathematics teachers.

<sup>4</sup> Student teachers who had at least a merit in mathematics or optional mathematics or other teaching qualifications before they entered college of education.

Hakin 1987; Robson 1995). Where a diversity of information is sought, different instruments are needed so that each can supplement the other to generate more adequate and meaningful data. Robson (1995), for instance, believes that, to obtain precise and generalisable data this approach to data collection is desirable because the more the instruments differ the more the confidence a researcher has in any relationships.

#### **4.4.1. The school mathematics contents test (SMCT)**

This instrument was developed by the researcher, to collect data which will provide information on questions 4, 5, and possibly 6. The decision, by the researcher, to construct the instrument was based on three reasons:

- 1) Efficient, reliable and valid instruments are, for reasons explained in the introduction to this chapter, not easily obtained in Nigeria. These are published in foreign journals most of which are not available in Nigeria. Investigators are, invariably, forced to go the lengths of developing their own instruments; an exercise they would prefer to avoid because it is usually time consuming and energy sapping.
- 2) The instruments that are available contain test items which are often not suitable because they use terms that are not culturally familiar to Nigerian society; and
- 3) to modify or adapt them for the study would not be proper; since the main objective of the decision to test was to measure student teachers' level of understanding of the contents of a specific mathematics syllabus: the NNMC. It was, therefore, necessary to construct a test that is based entirely on the content of that syllabus.

The SMCT, thus, contained 100 multiple choice objective items and is based entirely on the JSMC and the SSMC(gm) sections of the Nigerian National Mathematics Curriculum (NNMC). No item was written on the further mathematics [SSMC(fm)] section of the



syllabus. This is because NCE mathematics teachers in Nigeria are not officially expected to teach further mathematics courses or classes in the senior secondary schools. We now discuss how the instrument was developed and constructed, its structure and validation.

(a) *Construction*

The construction of the instrument itself was carried out based on Thorndike and Hagen's (1977 p. 216) steps for constructing multiple-choice items for a test as follows:

On the basis of the NNMC, some objectives have been stated in the syllabi guidelines of many mathematics programmes in Nigeria; For example, the JSCE syllabi of the various state schools boards; the WAEC syllabus for the SSC examination (Revised, 1992), the Joint Admission and Matriculation Board (JAMB) syllabus for university admission selection, and the NTI primary school teachers' mathematics training programme (1992). Given these sets of objectives and the sample population, an analysis was made of a selected number of reports and recommendations in order to elicit the aims of mathematics programmes for secondary schools. The analysis was carried out in three stages. First, the general and specific statements of objectives were identified. Second, the aims were classified as to both content and behavioural terms. Third, information on the frequency of the mention of objectives was recorded on a content area chart in terms of average percentage of time spent on each topic.

In all one-hundred and thirty-eight objectives, in terms of behaviours that school mathematics teachers should be able to demonstrate, were extracted. Also four major content areas (number and numeration, algebra, geometry and trigonometry, basic statistics) and application, which pervades the four content area, were identified.

To ensure that the test included items on a representative sample of the sampled objectives, a test specification was prepared. It defined how many items would be

included in the test and how they would be apportioned between the syllabus sections and objectives. The proportion of the items allocated to the various syllabus sections reflected the relative importance of the sections. The procedure followed was to allocate a percentage weighting for each section and then to calculate the equivalent number of items by reference to the test's length. The number of items allocated to each section were similarly subdivided among the objectives. The time allowed (3 hours) for the test was generous because the test was not intended as a measure of speed of work.

Test items were then written for each objective. Each item was made to test specific objective(s) that a mathematics teacher should be able to demonstrate to show competence in or understanding of the particular skill, topic or concept in a content area.

(b) *Structure*

It was then decided to sort the items, in a content versus behaviour grid, according to some behavioural outcomes which each item appeared to be measuring. The idea was to allow mathematics content to be tested in relation to behavioural skills or knowledge expected from a learner after exposure to training curricula content.

In the third international survey of school mathematics conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA) in which 16 countries participated, four levels of behaviour, computation, comprehension, application and analysis, were identified. The four levels of behavioural outcomes are expected to guide the teaching of mathematics in the classroom. If teachers teach mathematics bearing in mind the demands of these behavioural levels, it would be expected that students would be able to operate and exhibit the behavioural outcomes accordingly. To be in a position to inculcate these behaviours in their students,

teachers must themselves be able to demonstrate the skills/knowledge associated with them. The present study investigated student teachers' ability to demonstrate three skills derived from the behavioural levels identified for the international study. Key words and phrases that describe these skills, are listed in Table 4.4.

**Table 4.4. A TAXONOMY<sup>5</sup> OF BEHAVIOURAL SKILLS IN MATHEMATICS TEACHER EDUCATION**

SKILLS (IEA's equivalent hierarchical levels)	KEY WORDS AND PHRASES
<b>1. Definitional and General Knowledge (DGK)</b> <i>(Knowledge and Comprehension)</i>	Ability to: -identify by name. -recognise symbols -define meaning of symbol -give a specific fact -state concepts, rules or principles -recognise concepts -recognise principles, rules and generalisations -transform problem elements from one mode to another -follow a line of reasoning -read and interpret a problem
<b>2. Process Skill (PS)</b> <i>(Computation and Application)</i>	Ability to: -read and interpret a problem -display knowledge of terminology -recall specific facts -carry out algorithms -to solve routine problems -identify relevant and appropriate processes -select and carry out correct operations -recognise patterns, isomorphism & symmetry
<b>3. Problem solving and Application Skills (PsAS)</b> <i>(Analysis, Synthesis &amp; Evaluation)</i>	Ability to: -produce a plan -apply principles to new situation -apply abstract knowledge to practical situation -identify unstated assumptions -solve non-routine problems -discover relationships -construct and criticise proofs -formulate and validate generalisation -make comparisons -analyse data

<sup>5</sup> Adapted from Osafehinmi, I. O.(1992); "A study of the behavioural levels of operations in the teaching and learning of mathematics" in *Education for All: The Challenge of Teacher Education*, Vol. 1 No. 1 pp. 564-578

(c) *Validation*

In order to establish content validity, the one-hundred and thirty-eight items and the list of objectives were submitted for comment and suggestions to three judges who were themselves concerned with mathematics teaching and mathematics preparation of teachers. One of the judges was engaged in the training of NCE mathematics teachers in Nigeria. One was a lecturer in mathematics education and was involved in the preparation of mathematics test materials for the Comparative Education Study and Adaptation Centre (CESAC) of the University of Lagos in Nigeria. The third judge was a Professor of Mathematics Education and a former Dean of the Faculty of Education at the University of Jos. This judge was originally appointed, by the University of London, Faculty of Education, as the local adviser for this study. These three judges examined the suitability of the mathematics contents of the test and the appropriateness of item setting and method of questioning.

As a result, items were subjected to comments by these judges and those that did not meet the requirements were revised, rewritten or discarded. One-hundred items, which were later agreed upon as good and in agreement with the objectives and content areas of the NNMC by the judges, were then used in the test. Table 4.5 summarises the distribution of the 100 items of the SMCT according to the four main content areas and the three behavioural skills.

**Table 4.5 DISTRIBUTION OF 100 TEST ITEMS IN THE INITIAL SMCT**  
(content areas by behavioural levels)

Behavioural Skills ↓	Content Areas								
	Number and Numeration (NN)		Algebra (ALG)		Geom. & Trig (GEOT)		Basic Stats. (STAT)		Total
	Item Nos.	Total	Item Nos.	Total	Item Nos.	Total			
<b>Definitional and General Knowledge (DGK)</b>	1, 5, 6, 9, 10, 11, 12., 28	<b>8</b>	25, 36, 37, 71	<b>4</b>	38 45 46 47 48 50 61 63 80 81 84 85 89	<b>13</b>	64 66 67	<b>3</b>	<b>28</b>
<b>Process Skill (PS)</b>	3, 4, 7, 8, 13, 14, 15, 16, 17, 18, 19, 20, 21, 26, 27, 43, 53, 54, 61, 69, 70, 72, 74, 87, 91, 92, 98.,	<b>27</b>	23, 24, 31, 32, 33, 34, 35, 39, 41, 42, 44, 68, 73, 75, 76, 77, 78, 90, 93, 95.	<b>20</b>	40 49 51 52 55 56 57 58 59 60 62 79 82 86 88 96 97 99 100	<b>19</b>	65	<b>1</b>	<b>67</b>
<b>Totals</b>		<b>35</b>		<b>24</b>		<b>32</b>		<b>4</b>	<b>95</b>
<b>Problem Solving and Application Skills (PsAS)</b>	2, 20, 22, 29, 30, 43, 60, 72, 83, 94,								<b>10</b>
<b>TOTAL</b>									<b>105 **</b>

\* Five items (viz.: 20, 43, 60, 61, and 72) appear in more than one group. The total number of items in the test is, however, 100

The draft instrument was trial tested in a pilot study in July/August 1993. The response showed that certain items needed to be rephrased and some needed to be explained further because a large percentage of students did not understand or react to them.

For instance, the original question 54, which sought to test the objective that a student teacher should be able to determine the actual dimension of a plane figure from a scale drawing, which read:

*54. What is the actual dimension to the nearest metre of the rectangular piece of land below drawn to a scale 1 cm to 20,000?*

*Answer \_\_\_\_\_*

was modified to read:

*54. The actual dimension of the rectangular piece of land below drawn to scale 1 cm to 20,000m is approximately equal to:-*

- (a) 5.5m by 1.5m*
- (b) 15,800m by 40,000m*
- (c) 110,000m by 30,000m*
- (d) 17,500m by 30,000m ,*

when participants pointed out that apart from the fact that the phrase "approximately equal to", is better than "to the nearest metre" the question, as it stood without the four alternative responses, left room for different answers which would, inevitably, lead to subjective scoring.

As the pilot study is to serve as a mirror or yardstick with which to measure the success or failure of the main research, this first set of questions was re-examined and the "offending" items were either rephrased or explained further as appropriate. The instrument was then resubmitted to the judges in October 1993 for further comment.

The final draft of the test instrument was collected back from the judges in January 1994. This is the test instrument that was administered during the actual fieldwork to student teachers in June 1994. The list of objectives and the SMCT appear in Appendices B and C respectively.

However, on arrival in UK in October 1994, the researcher was encouraged<sup>6</sup> by the availability of better research facilities, ready and helpful criticism to take a closer look at and more detailed examination of the SMCT instrument. The exercise revealed that the SMCT, as it was with the 100 items, could not survive the statistical requirement of a good test. More careful analysis and examination of the items, making use of new facilities, showed that:

- i. typographical errors had:
  - (a) rendered some test items ambiguous (e.g. items 19, 25, 38 and 62);
  - (b) meant that some items had no correct answers or had more than one correct answers among the alternative responses provided (e.g. items 28, 33, 46, 96, and 88) and;
- ii. because of the way they were worded some other items (e.g. items 26, 40, 41 and 78) were either too difficult or outside the scope of the NNMC syllabus and therefore not fitted as items for the purpose of the research.

It was also discovered that the "scoring mask" used earlier to score student teachers' response to the SMCT contained wrong responses to some items. A decision was then taken to:

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<sup>6</sup> The researcher here acknowledges, with thanks, his indebtedness to the advice and helpful criticism from Mr Geoff Woodhouse of the Mathematical Sciences Department at the Institute of Education, University of London. Much of the encouragement that sustained this part of the study is owed to him.

(a) discard 13 bad items out of the original 100 items of the SMCT, thus leaving 87 good items, (The discarded items are items 19, 25, 28, 33, 38, 40, 41, 46, 57, 62, 78, 86, and 88);

(b) remark questions 20, 66, 73, 76 and 89.

It was reasoned that this is the best thing to do since it would have been financially prohibitive and perhaps impossible to repeat the fieldwork. Possible effects of the change to the instrument on the outcome of the analysis are discussed in chapter 6. Table 4.6 shows the distribution of the 87 items after these changes were made.



Table 4.6. DISTRIBUTION OF 87 ITEMS IN THE CORRECTED SMCT  
(content areas by behaviour skills)

Behavioural skills ↓	CONTENT AREAS								
	Number and Numeration (NN)		Algebra (ALG)		Geom. & Trig (GEOT)		Basic Stats (STAT).		Total
	Item Nos.	Total	Item Nos.	Total	Item Nos.	Total			
<b>Definitional and General Knowledge (DGK)</b>	1, 5, 6, 9, 10, 11, 12.	7	36, 37, 71	3	45, 47, 48, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100	11	64, 66, 67	3	24
<b>Process Skill (PS)</b>	3, 4, 7, 8, 13, 14, 15, 16, 17, 18, 20, 21, 26, 27, 43, 53, 54, 61, 69, 70, 72, 74, 87, 91, 92, 98,	26	23, 24, 31, 32, 34, 35, 39, 42, 44, 68, 73, 75, 76, 77, 90, 93, 95.	17	49, 51, 52, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100	14	65	1	58
		33		20		25		4	82
<b>Problem Solving and Application Skills (PsAS)</b>	2, 20, 22, 29, 30, 43, 60, 72, 83, 94,								10
<b>TOTAL</b>									<b>92 *</b>

\* Five items (viz.: 20, 43, 60, 61, and 72 appear in more than one group. The total number of items in the final test is, however, 87

#### **4.4.2. The content check-list**

This was a check-list for checking the contents of the mathematics teacher training programmes ( see Appendix D). It was developed by the researcher to facilitate the analysis of the 12 sample programmes. Its construction, validation and application is described in detail in chapter 5. In it, provision was made for the categories of contents, in a teacher education programme, defined in chapter 5 (see Table 5.1). Data collected with this check-list was used to find answers to questions 1, 2 and 3 of this research.

#### **4.4.3. Teacher-trainers Assessment of Mathematics Programmes (TAMP) Questionnaire**

One questionnaire was used for this study. This is the Teacher-trainer Assessment of Mathematics Programme (TAMP) questionnaire ( see Appendix E, page 336). The idea was to use the questionnaire to gather teacher trainers' views on mathematics teacher education in Nigeria in general and in their respective institutions in particular. It was hoped that information from this would supplement information from the content analysis check-list of section 4.4.2 in providing answers to questions 1, 2, 3 and possibly 6 of this research. It might also, help in explaining some of the results of the analysis of data gathered with the SMCT.

The first two parts (sections A and B) of the TAMP sought background information about the respondents. The data obtained here were used to cross-check the sampling criteria regarding the experiences and qualifications of selected teacher trainers. The third part (section C) consisted mainly of the key questions, which sought to collect information on how respondents perceive mathematics teachers training programmes in Nigeria and in their respective colleges and whether or not they are aware of the general objectives of mathematics instruction and the behavioural levels which student teachers must demonstrate at the terminal point of their training.

The basic assumption underlying this part was that unless the teacher trainer is aware of the goals of mathematics teacher education, as stipulated by the Nigerian Policy on teacher education, neither the teaching of mathematics nor the training of mathematics teachers can be handled meaningfully.

Some questions in the questionnaire are deliberately open-ended, and were considered by the researcher as appropriate and suitable for obtaining what the respondents might view as appropriate answers (opportunity for self expression), and to allow respondents to answer adequately, in detail and if possible, to qualify their answers. Though open-ended questions do have some disadvantages, such as difficulty in coding, nevertheless, Bradburn and Sudman, (1979) suggest that they are rather consistently superior to closed-ended questionnaire especially when threatening issues are being studied as they allow respondents to express exactly what they want. A typical example of a question of this type is question 10 which asked respondents to "Describe your understanding of the objectives of mathematics teacher education in Nigeria" rather than giving a list of objectives and asking them to select from the list.

The draft questionnaire was also trial-tested at the same time as the SMCT in July/August 1993. The draft questionnaires were sent out to six colleagues. The instruction which accompanied the questionnaire requested these colleagues to advise the author on the following aspects of the questionnaire: length, clarity of questions suitability for teacher trainers in CoEs, omissions and other relevant suggestions. After three weeks these colleagues were visited to follow up the questionnaire. The visit proved quite useful in identifying issues of ambiguity, clarity of statements and omissions. For instance, certain status/ranks (principal lecturer and lecturer III) peculiar to colleges of education were omitted in item 6 of the questionnaire and the correction was done appropriately. Second, they also suggested that item 15 be added to give

teacher trainers the opportunity to express their suggestion for improving training programmes.

#### 4.5. Administration of Instruments for data collection

The first administration of the SMCT and the TAMP was during the pilot study. This was carried out as a validation exercise specifically to refine and sharpen the instruments intended for the main fieldwork. It was carried out in three colleges of education located around Jos in the Plateau state of Nigeria and involved 30 students teachers, and six teacher trainers all selected at random from the three colleges. Table 4.7 gives the distribution of the sample population for the pilot study.

**Table 4.7: SAMPLE POPULATION FOR PILOT STUDY**

INSTITUTION	STUDENTS		TRAINERS (sex)
	male	female	
College of education, Gindiri	8	2	2 (1m 1f)
College of Education, Akwanga	6	4	2 (1m 1f)
Federal College of Education, Yola	9	1	1 (2 males)
SUMMARY	23	7	4 m 2f

There were two reasons for choosing these colleges. First, they were easily accessible to the researcher and second, they were each affiliated to a different university and therefore used different mathematics training programmes. They were, thus, for the purpose of the pilot study, considered as representing three distinct programme groups.

Five major benefits accrued from the pilot study. First it helped the researcher to determine the feasibility of the test for the actual fieldwork and to ascertain the appropriateness of the instruments. For instance, it was discovered that it would not be

proper to send the questionnaires and test materials by post to Heads of Departments of Mathematics of the colleges to administer to respondents. The benefit of personal contact and on-the-spot involvement was made obvious.

Second the researcher was able to estimate the non-response rate to be expected in the final study. It became apparent that the response rate was likely to be affected by postal delays and/or by communication difficulties within the colleges. For instance, two of the three pilot colleges had not received the packets after three weeks. In the one which received the packet the head of department was unable to find time to distribute the questionnaire or administer the test because of the rush to prepare student teachers for the NCE final examination due in August. This was one of the reasons why a decision was taken to zone the administration of the instruments during the actual fieldwork. This allowed the researcher to deliver both the TAMP and the SMCT by hand. The response rate was improved, in the case of student teachers, by the fact that it became a part of the design of the research to undertake the administration of the SMCT to this group in person. Although this was time consuming and expensive it, nevertheless, had the following advantages:

- a) It ensured that the tests reached the respondents and on time.
- b) It gave very little opportunity for respondents to collude with each other and thereby 'falsify' their responses..
- c) It produced a high percentage of instrument return rate in the case of the SMCT.
- d) It gave an opportunity for the respondents to obtain clarification for questions about which they had doubts.

The TAMPs were, however, sent through students teachers (who were present at the centres) to teacher trainers who could not turn up at the centre. This inevitably affected the response rate of the TAMP (see chapter 7)

The third advantage of the pilot study was that it helped the researcher to determine the adequacy or otherwise of the sampling procedure. The three CoEs used for the pilot study represented three of the twelve programme groups proposed for the actual fieldwork. A practice run of the research (for this is what the pilot study is) exposed some difficulties about the timing for the administration of the tests. It was discovered that the best time to administer the test was not July/August or January but in May/June. This was because in July/August students had all gone off into bush and other hidden places for private reading, in preparation for the final examination in August. In January students would just be returning from long Christmas vacation and, therefore, very unprepared for any test. On the other hand, preparation for the final examination in August would be in earnest in May/June and students would be most willing (and still available for lectures) to take any test, which, they hoped, might help them determine how well their reading had prepared them for the final examination. And since the main purpose of the SMCT was to determine student teachers' level of understanding of some skills and concepts in school mathematics it was best to test them in May/June; just before they graduated.

Fourth, it influenced the decision to carry out the administration of the instruments in the four zones chosen (see Table 4.8) which corresponded to the old geo-political divisions of the country before independence in 1960 (see Map in Appendix J).

The overriding consideration for zoning and choice of centres was accessibility and availability of facilities at the host centre. Also it reduced the number of test centres (and therefore, the cost of the field work) substantially from a possible 53 to exactly 4.

The zones and centres and the distribution of colleges of education for the purpose of the exercise is shown in Table 4.8

Table 4.8 ZONES AND CENTRES USED FOR THE FIELD WORK EXERCISE

ZONE	CENTRE	COLLEGES
<b>Zone A (NORTHERN)</b>	College of Education, Zaria	Kano, Zaria, Azare, Katsina, Bichi, Gombe, Potiskum, Gusau, Maidugiri, Waka-Bui, Gasua, Bama, Gumel
<b>Zone B (EASTERN)</b>	Alvian Ikoku College of Education, Owerri	Obudu, Umunze, Awka, Nsugbe, Eha-Amufu, Alvian, Enugu, Omoku, Afaha-Nsit, Akamkpa, Uyo, Port- Harcourt
<b>Zone C (WESTERN)</b>	Adeyemi College of Education, Akure	Adeyemi, Ijebu-Ode, Ikare-Ekiti, Oyo, Abeokuta, Ilesha, Ila-Oragun, Okene, Ilorin, Oro Akoka, Ijaniki, Asaba, Eki-Adolor, Agbor, Warri
<b>Zone D (MIDDLE-BELT)</b>	University of Jos, Faculty of Education, Jos.	Ankpa, Kafanchan, Mina, Gindiri, Kontagora, Pankshin, Katsina-Ala, Akwanga, Hong, Yola, Jalingo

Respondents who had to travel far to get to the centres had their travelling expenses refunded<sup>7</sup>. This ranged from 15.00 Naira to 55.00 Naira depending on the distance from a respondent's institution to the centre. Each of the 265 participants was also paid extra 15.00 Naira for lunch at the centre. At the time when these payments were made the gross monthly salary of an average university lecturer in Nigeria was 3400.00 Naira. The total cost actually paid out from the researcher's personal resources for this exercise was 14,475.00.

<sup>7</sup> I wish here to express my immense gratitude to the Provosts of colleges of education at Kano, Zaria, Katsina, Gombe, Maidugiri Gumel, Eki-Adolor, Yola and Jalingo for agreeing to bear the entire cost of sending students from their colleges to the centre for the test. Their kindness made it possible for me to be able to pay other participants with less difficulty.

Finally, the lesson of the pilot study influenced the decision to make letter contacts with the institutions and the centres to make arrangements well in advance. Bogdan and Biklen (1982) had found that contacting respondents, before administering tests, had increased the response rate in similar studies.

#### **4.6. Procedures for data analysis**

Two main factors usually influence the choice of procedures for data analysis.

- a) The type of data obtained from research using specific tools.
- b) The type of research questions being investigated.

However, irrespective of the type of data generated or the method used to collect data the major task is to find answers to one's research questions. This had a major influence on the kinds of procedures for data analysis chosen for this study.

Data for this study were gathered from different sources (documents, teacher trainers and student teachers), using three different data collection methods (content checklist, questionnaire and test). This was bound to generate data of different types and, therefore, required different methods of analysis. The following procedures were considered most suitable.

First (Chapter 5), in analysing the 12 sample programmes the content analysis technique was considered most suitable. This was because it is a technique that can be employed to collect data for and answer questions about category systems based on selected recording unit(s).

The technique came to prominence in the social sciences at the start of the twentieth century in a series of qualitative analysis of newspapers, primarily in the US. Since then it has been profitably extended to studies attempting to assess bias in school textbooks, assessing written curricula and course outlines and other course documents. It was therefore decided that content analysis technique would help to provide answers



to questions about the characteristic features, the content and the structure of the training programmes and their relationship to the school mathematics curriculum.

Second, each student was to circle one and only one response out of four responses in each question asked in the SMCT. A correct response was then scored 1 (one) and an incorrect response (or an omission) was scored 0 (zero). Aggregate scores were then compared with set criteria (see chapter 6) to determine the number of competent student teachers in each of the four content areas of the NNMC and each of three named behavioural levels. Data generated from this was, thus, in the form of counts in the cells of a multi-way contingency table. This could be analysed using nominal and percentage scales.

It was, however, thought that because of the type of questions we sought to answer with data from the SMCT, although nominal and percentage scales were useful first steps, in studying relationships between the variables, they did not allow for quantification or testing of that relationship. For this reason it was decided to consider some other indices that measured the extent of association as well as statistical test of the hypotheses that there was no association. The preferred procedures were the chi-square, the Cramer's V statistic and Tukey's Honestly Significance Difference<sup>8</sup>

The is because the data generated by the SMCT will result in counts in the cells of two-way and multi-way contingency tables suitable for analyses by the chi-square method and the Cramer's statistic. Also, Tukey's HSD test could be suitably applied to the means of aggregate scores to compare differences between programmes in student teachers levels of understanding of school mathematics subject matter.

The raw data collected, using the SMCT, were tabulated as shown in Appendix I-1 and the analysis presented in chapter 6.

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<sup>8</sup> A description of Tukey's HSD test is given in section 6.4 of chapter 6

Third, the questions asked in the questionnaire (TAMP) were mainly descriptive and associative statements. According to Robson (1995) the aim of descriptive questions is to identify the characteristics of an individual, a group, several sub-groups, a system or an object. Associative questions, he continued, focus on the pattern of the degree of association or covariance between two or more variables.

Descriptive and associative questions allow two main types of statistics to be used: descriptive and inferential statistics. Descriptive statistics, in this case, show the frequency distribution of subjects' responses on every item while inferential statistics provide an idea about whether the patterns described in the sample are likely to apply in the population from which they were drawn.

Because of the type of information being sought with the questionnaire and the nature of expected responses, the qualitative data analysis procedure (descriptive and inferential) was thought to be most suitable for analysing the data collected using the questionnaire. This was because the type of questions asked were those which sought the respondents' views, opinions and understanding about mathematics teacher education in colleges of education in Nigeria. In some instances, the respondents were asked to provide factual data with the aim of establishing a status-quo. It is therefore, the opinion of the researcher that data of this nature can best be made sense of through the qualitative interpretation (see chapter 7)

Finally, charts and tables were used extensively in all the analysis presented because they were considered useful and important in bringing out clearer pictures from the data.

#### 4.7. Summary

The methodology adopted for this research was dictated by the situation that existed in Nigeria at the time when the fieldwork was carried out. The military interregnum, and the instability that accompanied it, meant that decisions about sampling procedure depended on the feasibility of accessing a chosen college of education in order to collect a programme. This was because postal services were either not reliable or non-existence in most areas of Nigeria at the times.

Because the decision to sample in this way was likely to introduce some bias in the sample, it was decided to use more than one method to gather data for the research. The reasoning was that this approach would enable triangulation, which is known to reduce the effect of assumptions about representativeness of sample, to be applied. The three methods employed were content checklist, questionnaire and a test. The checklist was used to gather information on the contents of sample programmes; the questionnaire was used to solicit teacher trainers' views on training programmes and the test (SMCT) was used to gather information on prospective teachers' level of understanding of the subject matter of school mathematics in Nigeria.

It was hoped that the information generated with the three instruments would supplement each other and help the researcher to reach valid conclusions on the relationship of training content to school mathematics and to the needs of trainees. The data generated were analysed in chapters 5, 6 and 7 using appropriate statistical procedures.

## CHAPTER 5

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### ANALYSIS OF MATHEMATICS PROGRAMMES FOR TEACHER EDUCATION IN NIGERIA

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#### 5.1 Introduction

One purpose of this research was to establish the practice in pre-service teacher education for mathematics teaching in Nigerian schools. To achieve this, twelve written programmes of mathematics teachers education in Nigeria were selected and examined. Specifically, the purpose of this chapter is to analyse the data gathered with the content checklist in order to describe:

- (a) the conditions or programmes that exist in Nigeria for the training of school mathematics teachers;
- (b) the differences among the training programmes;
- (c) the relationship between training curricula and the school mathematics curriculum (The NNMC) in Nigeria.

The method employed to examine the twelve sample programmes was similar to the content or documentary analysis procedure described by Holsti (1968) as a "technique for making inference by systematically and objectively identifying specified characteristics or messages".

Krippendorff (1980) reports that the techniques was very useful in a series of quantitative analyses of newspapers, especially in studies showing how 'worthwhile' news items were being increasingly dropped in favour of gossip, sports and scandals. The techniques was, also, profitably used in the United States in studies that attempted to assess bias in school textbooks, and the depiction of favourable or unfavourable attitudes to blacks, females and homosexuals both in texts and other publications.

Robson (1995) reports that it is a suitable method for gathering useful and important data especially in a situation, such as the present, "where it is hard to see what other method could provide the detailed information we require about programmes planned, developed and written without the researcher's presence". Instead of directly observing, or interviewing, or asking someone to fill in a questionnaire for the purpose of our enquiry, we dealt with some artefact (document) entirely concerned with the specific purpose of our research.

Holsti (1968), however, suggests three characteristics (objectivity, system and generality) that distinguish content analysis from any careful reading of documents and went on to explain that in order to achieve this the researcher has to consider how data are to be coded. This should be done in such a way that the coding represents a precise description of the content characteristics. Holsti suggests a procedure to be followed in order to ensure that the analyses have the three characteristics. The researcher should:

- (a) define the contents of the document(s) in terms of categories that represent the elements of the theory to be investigated. (The categories should, as much as possible, be exhaustive, to ensure that every item relevant to the study can be classified; and mutually exclusive, so that no item can be scored more than once within a category set.);
- (b) define what units of contents are to be classified;
- (c) describe the system of enumeration to be used.

The definitions of categories and units of contents, and the description of system of enumeration used in this study are presented in sections 5.2, 5.3 and 5.4 of this chapter, respectively.

## 5.2. Definition of categories of programme contents

Mitzel (1960) dealt with teaching in terms of three factors; viz. presage, process and product. Later Clarke (1971) applying this terminology classified elements found in a teacher education programme in terms of presage factors or prior decisions (such as objectives of the training programme, entry requirements, methods of selection etc.), process factors or the treatment proposed in order to achieve the stated aims and objectives of the programme (e.g. duration and mode of training, method of teaching/training, number of credit hours or credit units, prescribed courses and activities) and product factors or the actual behaviour to be produced (usually given in statements pertaining to criteria for certification and are catered for through the provision of evaluation and assessment procedures to be used).

The elements of these three factors, together, constitute the characteristic features of a training programme. These elements, with the possible exception of prescribed courses and activities, are headings for specific basic information that appear in training programmes. They, together, determine the structure of a programme. Their meanings are fairly obvious and universal. We shall not, therefore, define them differently in this study. Appendix H-2 is a record of information, under eight of these headings, extracted from the twelve sampled programmes and given in full and exactly as they appear in the programmes. We shall examine that Appendix in detail later.

However, prescribed courses and activities constitute the curricula contents or what is referred to as the syllabus. They differ according to types, aims and objectives of training programmes. Even within programmes with similar aims and objectives there can be differences in their composition.

Besides, teaching is a complex activity and therefore teacher education is likely to be even more complex; so that, attempting to select activities and experiences for inclusion

in programmes of teacher education is a formidable task. The activities and experiences selected by one designer might differ from those of another and classification of selections in a programme by one researcher may also differ from that of another researcher. These, therefore, present some difficulty in trying to categorise them.

But despite these difficulties, courses and activities can be grouped according to the type of behaviours they claim to inculcate. In this study, we are interested in identifying the characteristic features of programmes for training mathematics teachers in Nigeria. In other words we are interested in identifying and classifying courses and activities in teacher education programmes in Nigeria in terms of teachers' knowledge components that are identified by research as essential for effective mathematics teaching.

A good approach would be to define categories of programme contents, in terms of these components, based on information and recommendations from various primary sources such as research, reports, and policy documents on teacher education in Nigeria. Our review of literature was of value in this respect.

To begin with, we noted in chapter 3 section 3.7 that the Nigerian National Policy on Education (FME, 1981) gives four categories of knowledge which a teacher training programme in a college of education in Nigeria needs to provide in order to ensure that a student teacher is well prepared to implement the national curriculum. These are: (a) general studies (defined as courses essential to Nigeria); (b) foundation studies (defined as principles and practice of education, (c) studies related to the student teacher's intended field of teaching (e.g. mathematics) and (d) teaching practice. The policy does not, however, give a clear guide on the nature or design model to be used to construct the training programme, nor does it specify courses to be included or the method of teaching to be adopted. Each training institution is left free to decide on the

pattern of its design. Implicit in this recommendation, however, is an awareness of the notion that a teachers' knowledge base is multi-dimensional.

The National Commission for Colleges of Education (NCCE) Guideline Document to CoEs No. 1 (NCCE, 1990a) goes a little further. It gives specific suggestions on what courses should be included in the four categories recommended in the National policy.

The courses suggested by the NCCE are as follows : For

- (a) *general studies*, it suggests: use of English, philosophy and logic, history and philosophy of science, and Nigerian peoples and culture;
- (b) *foundations*, it suggests: theory of education, principles and practice of education, philosophy of education, psychology of education and history of education;
- (c) *specialist subjects*, it gives a list of 49 choices which included mathematics;
- (d) *teaching practice*, it recommends that student teachers should spend at least 12 weeks in schools teaching mathematics as part of their training.

Again this document, like the National policy, does not prescribe. It merely suggests. The choice of what courses and experiences are to be included in a particular programme and how they are to be arranged and taught is still left to each institution.

Also, the Mathematics Curriculum Development Circular Vol. 3 No. 2 (NCCE, 1990b), which was published immediately after the guidelines by the same Commission, recommends that NNMC contents should be taught as a specific course to be designated "School Mathematics Content" or "Basic Mathematics" in all mathematics departments of colleges of education where mathematics teachers are being trained. The reasoning is that some topics of the NNMC are new and, therefore, student teachers are unlikely to have studied them during their secondary school years. It then suggests that "the teaching of mathematics should be based mainly on lectures, tutorial



and problem solving methods” and that “...discovery method be emphasised.” What this means is not, however, very clear. Are student teachers to be taught using these methods, on the assumption that they would become used to the approach and, hopefully, employ it in their subsequent teaching after graduation? Or are there to be specific courses on how and when to use each of the approaches in a mathematics classroom? In other words, whether and what courses, in methodological approaches, for example, should be taught in colleges of education for this purpose are not made clear. Such vagueness, as is exhibited in the three documents cited above, resulted in a wide variety of different activities and experiences and arrangements for the training of mathematics teachers in Nigeria.

However, in 1991 the National Commission for Colleges of Education in Nigeria (NCCE), through its second policy document “*Minimum Standards: A Clarification*” (NCCE, 1992), directed all validating universities to ensure that all teacher education programmes in colleges of education met the country's educational needs as outlined in the National Policy and the various school curricula published by the Federal Ministry of Education. The result of this directive is reflected in the recommendation and adoption of “harmonised syllabuses” by each group of colleges of education affiliated to a particular university - a sort of local common training programme. For instance, students at CoEs Zaria, Kano and Kafanchan were trained using the same mathematics teachers training programme from Ahmadu Bello University; students at CoEs Pankshin, Akwanga and Katsina-Ala, use the harmonised mathematics programme from University of Jos, while CoEs at Awka, Owerri, Nsugbe and Ehamufu subscribe to the University of Nigeria programme, and so on.

These efforts were, however, localised in the sense that the so-called harmonised syllabuses could be prescribed by a validating university only to colleges affiliated to it.

In this way, mathematics teachers training programmes in colleges of education still varied from college to college depending on the university of affiliation. To identify, classify and compare activities and experiences in these programmes is the main task of this section.

The first three policy documents cited above, provided us with four categories of contents which, in the Nigerian context, it is thought that a relevant mathematics teacher training programme should provide. This study is about teacher education in Nigeria and the three documents are official policy specifications of what are considered relevant contents of a teacher education programme in that country. Their recommendations and suggestions are therefore important for our purpose. We list these categories of contents once more, for clarity. They are:

- General Studies courses.
- Educational Foundation courses.
- Specialist subject (mathematics courses including courses in school mathematics contents or basic mathematics, and courses on methods of teaching topics in the specialist area etc.)
- Teaching practice.

Also, in our survey of literature, we noted that writers of all shades of opinion recognise some features as broad components of knowledge for teacher education. (e.g. Carnegie Task force, 1986; Holmes Group, 1986; Shulman, 1986; Harel, 1994; Fennema & Frankel, 1992; Grossman, 1990; Ball, 1990a etc.). For instance, we showed in chapter 3 that it is widely accepted that a teacher has to know how to teach and has to have something which he would teach, so that there are two widely recognised dimensions of a teacher's knowledge around which categorisation and classification of other components of a teacher's knowledge could be organised. These are the *what to* and

the *how to* teach. Traditionally these are referred to as *subject knowledge* and *pedagogical skills* respectively. Recently, pedagogical skill is referred to as pedagogical knowledge.

Ball (1990a) further developed a conceptual framework for exploring teachers' subject matter knowledge specifically in the area of mathematics. She claimed that understanding mathematics for teaching entails both *knowledge of mathematics and knowledge about mathematics*. She then defined knowledge of mathematics as knowledge of topics and concepts including knowledge of procedures and relationships among topics and concepts, and knowledge about mathematics as knowledge about the purpose, nature, beliefs and history of mathematics (Harel, 1994). These two make up the what to teach. Without these it is hard to see the purpose of going into a classroom to teach mathematics.

Similarly, pedagogical knowledge is differentiated according to four types: *general pedagogical knowledge, pedagogical content knowledge, context knowledge* and *practical knowledge*. The first two are regarded as professional components of teachers' knowledge base, the third as the vocational component relevant to a specific environment/society. Practical knowledge is the skill acquired through actual teaching or observation of expert teachers. These were explained in chapter 3 of this study. Again, without these there will be no sense in talking about teaching as a profession.

There are, thus, six widely recognised components of a teacher's knowledge, the possession of which, it is assumed, makes a good teacher. And by implication, a mathematics teacher education programme aspiring to be relevant in a given context must provide activities and experiences that will inculcate these component knowledge in a student teacher. As shown in chapter 3, section 3.7 (see also Table 3.1) the four

specific requirements of the three Nigerian policy documents cited previously are accommodated within these six components.

Thus, elements to be found in a mathematics teacher education programme in Nigeria, should be courses that will, apart from catering for school mathematics objectives of the country, inculcate these components of teacher knowledge. It was, therefore, possible to organise the definition of categories of elements of a teacher training programme in Nigeria around these widely accepted components of teachers' knowledge, to define coding units based on those elements and to classify the units according to the knowledge components using a specified enumeration system and a checklist.

This ensured an objective analysis since it was carried out on the basis of explicitly formulated rules which enabled two or more persons to obtain the same or similar results from the same documents (see section 5.6). It also ensured a systematic analysis since the inclusion and exclusion of content or categories was done according to consistently applied criteria of selection and thus eliminated analysis in which only materials supporting the investigator's hypotheses are examined.

Also, courses found in the programmes were accommodated within the six components. The definition of categories, therefore, represented the actual elements of our theory. And by splitting the six categories into twenty-five sub-categories, that are easier to described, it further ensured that every element of item relevant to the study could be classified and that categories were, as far as is possible, exhaustive and mutually exclusive.

The definitions of categories, with the full sub-category list and explanations, are given in Table 5.1. This provided the framework for the analysis presented in this chapter.

**Table 5.1 DEFINITION OF CATEGORIES OF COURSES AND ACTIVITIES IN PROGRAMMES FOR MATHEMATICS TEACHERS EDUCATION IN NIGERIA**

DIMENSIONS OF A TEACHER'S KNOWLEDGE	CATEGORIES	SUB-CATEGORIES	EXPLANATION
<b>SUBJECT MATTER KNOWLEDGE</b>	1. Knowledge of mathematics	1.1 School math. contents	School mathematics topics or concepts, including knowledge of procedure and relationships among these topics and concepts, taught as a course(s) in training colleges.
		1.2 Non-school maths content	Mathematics courses in training colleges dealing with topics or concepts not in the Nigeria National mathematics Curriculum (NNMC)
	2. Knowledge about mathematics	2.1 Purpose of math.	Why we study maths.
		2.2 Nature of math.	Structure, composition and patterns in maths
		2.3 Belief about math.	What is maths? Philosophical issues.
		2.4 History of math.	Including history of mathematics teaching in Nigeria
<b>PEDAGOGICAL KNOWLEDGE</b>	3. General Pedagogical Knowledge	3.1 Theory of Education	General principles and practice of education (e.g. General principles of instruction)
		3.2 Philosophy of Education	What is education? What is an educated person? What is learning? What is moral education, discipline and punishment? etc.
		3.3 Psychology of Education	Psychological theories about learning (e.g. Human development, child development, how children learn. and so on.

		3.4 Curriculum Studies	Curriculum planning, design, development and implementation. Curriculum and Instruction.
		3.5 Management Skills	Classroom management, Discipline, reward and punishment. etc.
		3.6 History of Education	History and development of education in Nigeria or in general.
		3.7 General Studies	Use of English, philosophy & logic, history of science. (Required by the NPE)
	4. Pedagogical Content Knowledge	4.1 Lesson planning in mathematics	Including taxonomy of objectives and lesson presentation.
		4.2 Psychological principles of math teaching and learning.	Works of prominent personalities in math education (e.g. Bruner, Gagne, Piaget, Dienes, Sawyer, etc.
		4.3 Teaching Methods and Approaches	Methods of teaching various topics, concepts and skills in math including common errors in math.
		4.4 Assessment and Evaluation skills in math	Including diagnosis and remedation of difficulty in math learning.
	5 Context Knowledge	5.1 The Nigerian people and Culture	Character and culture of the community in which the school situates. (This is one of the requirements of the National Policy)
		5.2 Governance of school	How to organise and run a school and control students and other personnel.

		5.3 Financing of school	
		5.4 Educational Administration & planning.	
<b>PRACTICAL KNOWLEDGE</b>	6 Practical Experience	6.1 Traditional teaching practice 6.2 Micro-teaching 6.3 Peer-group teaching 6.4 School-based training	Practical experience gained during training through having taking part in any one or all of the four sub-categories in this category..

### 5.3. Definition of coding units

In addition to deciding on categories, it is necessary to select recording unit(s). Holsti classifies recording units typically used in content analysis as either: the single word or symbol; the theme; the character (person) or characteristic (thing); the paragraph, sentence or other grammatical unit; and the whole item or other possibilities which suggest themselves for particular tasks.

In this study, a unit was the title (theme) of each course listed in a training programme and was defined as a word or a group of words denoting the type of activity or experience to be carried out or the type of fact, concept or principle to be learnt. The topics under each unit were examined for fit, in order to decide where in the range of sub-categories the unit fitted logically. For example, if the group of words "history of mathematics" was a title (theme) of a course denoting, at first sight, a unit in the content category identified as "knowledge about mathematics", the topics: pre-historic mathematics, development of mathematics in ancient times, the renaissance and mathematics, etc. were each examined for fit in order to confirm that they together, in fact, were suitable topics of the unit.

If a topic was found not to fit within a unit, it was examined to see if it fell within another unit in the same or different category or if it necessitated the definition of a new category

or sub-category. It was then treated appropriately. In the very rare case where it did not fall within any of the defined sub-categories it was decided to define a suitable sub-category into which it would fit and to classify it accordingly. No such case did, however, occur.

#### **5.4. Description of the Enumeration system used**

According to Holsti, a decision has to be made between whether the unit of enumeration is simply that a category has occurred, or how often it has occurred. The choice here was to record in the latter way, with some slight modification, using a checklist as the instrument for data collection. The modification was to record, also, the number of credits allocated to a course in a programme. This gave us an idea of the weighting (hence importance) attached to a unit in a programme. Also, apart from the impression gained from the examination of a unit for depth of treatment, recording the weighting given to a topic in the form of credits provided us with an index with which to compare similar units in different programmes.

#### **5.5. Description of the coding instrument**

The checklist (see Appendix D) had four main column sections. The first section was a list of the categories, the second was a list of sub-categories and had a tally grid for checking (✓) each time an appropriate unit occurred. The third section was for recording the number of credits allocated to a unit checked in a sub-category in the preceding section of the checklist. The last section was for totals of occurrences of units and the sum of credits.

This way it was possible to say whether or not a category or a sub-category had occurred and the "weight" of the occurrence. The two pieces of information helped the researcher in making decisions on the question of the similarity or otherwise of the 12 programmes examined. Tables 5.2 and 5.3 show the summary of the information (data)



gathered using the checklist. In these tables and in the discussion that follows, programme are coded by uppercase alphabets from A to L; categories of contents are code by numbers from 1 to 6 and sub-categories by 1.1, 1.2, 2.1, 2.2..... to 6.4 as the case may be. The definition of categories and sub-categories are those described on the content analysis schedule in Table 5.1.

Table: 5.2 CONTENT ANALYSIS RESULTS ACROSS PROGRAMMES

Category	Sub-Category	A	B	C	D	E	F	G	H	I	J	K	L
1	1.1	3	6	3	6	3	6	3	6	3	6	3	6
	1.2	21	61	21	60	20	57	21	59	21	61	17	50
	c												
	u												
2	2.1	-	-	-	-	-	-	-	-	-	-	-	-
	2.2	-	-	-	-	-	-	-	-	-	-	-	-
	2.3	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	1	2	1	2	-	-	1	2	-	2	1	2
3	3.1	2	4	1	2	2	4	2	4	2	4	2	4
	3.2	1	2	1	2	1	2	1	2	1	2	1	2
	3.3	2	4	2	4	2	4	2	4	2	4	2	4
	3.4	1	2	1	2	1	2	1	2	1	2	1	2
4	4.1	1	2	1	2	1	2	1	2	1	2	1	2
	4.2	1	2	1	2	1	2	1	2	1	2	1	2
	4.3	2	4	3	6	3	6	2	4	3	6	2	4
	4.4	-	-	-	-	-	-	-	-	-	-	-	-
5	5.1	1	2	1	2	1	2	1	2	1	2	1	2
	5.2	-	-	-	-	-	-	-	-	-	-	-	-
	5.3	-	-	-	-	-	-	-	-	-	-	-	-
	5.4	1	2	-	-	1	2	-	-	1	2	-	-
6	6.1	2	6	2	6	2	6	2	6	2	6	2	6
	6.2	-	-	-	-	-	-	-	-	-	-	-	-
	6.3	-	-	-	-	-	-	-	-	-	-	-	-
	6.4	-	-	-	-	-	-	-	-	-	-	-	-

Key: c = The number of units (courses) in a category/sub-category.  
 u = Total credit hours allocated to a sub-category. Categories and sub-categories are as defined in Table 5.1

Table 5.3. SUMMARY OF CONTENT ANALYSIS RESULTS ACROSS PROGRAMMES

Dimension	Category	PROGRAMME												Total	mean	sd	range										
		A	B	C	D	E	F	G	H	I	J	K	L														
Subject Matter Knowledge	1	c	24	24	23	24	21	17	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	252	21.00	2.35	20-24
		u	67	66	63	65	61	50	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	727	61.00	4.94
	2	c	1	1	0	1	1	0	2	0	2	0	0	1	0	0	0	0	0	0	0	0	0	8	0.67	0.624	0-2
		u	2	2	0	2	2	0	4	0	0	2	2	0	0	2	0	0	2	2	0	0	0	16	1.33	1.247	0-4
Pedagogical Knowledge	3	c	9	9	9	14	12	12	10	11	13	12	11	12	12	12	12	12	12	12	12	12	12	134	11.00	1.64	9-14
		u	18	18	18	28	24	24	20	24	26	26	22	24	24	24	24	24	24	24	24	24	24	272	23.00	3.45	18-28
	4	c	4	4	4	4	6	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5	55	4.58	0.67	4-6
	u	8	8	8	8	12	13	12	12	12	10	12	9	12	12	12	12	12	12	12	12	12	12	124	10.3	2.02	8-13
	5	c	2	1	2	1	1	3	3	5	3	2	3	2	3	3	3	3	3	3	3	3	3	29	2.4	1.16	1-5
		u	4	2	4	2	2	6	6	10	6	4	6	6	6	6	6	6	6	6	6	6	6	58	4.8	2.33	2-10
Practical Skill	6	c	2	2	2	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	1.50	0.5	1-2
		u	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	72	6.00	0	6
<b>TOTALS</b>		c	42	41	40	43	46	37	42	42	42	40	38	43	43	43	43	43	43	43	43	43	43	496	41.00	2.39	32-51
		u	105	102	99	111	113	97	108	112	110	108	98	108	108	108	108	108	108	108	108	108	108	1271	106.0	5.60	97-113

Key: c = The number of units (courses) in a category/sub-category.  
 u = Total credit hours allocated to a category in a programme. Categories and sub-categories are as defined in Table 5.1

### **5.6. Validity and reliability of the coding instrument**

When using a schedule (such as a checklist) as an instrument for data collection, an important question is how good is the instrument. In other words, how reliable and how valid is the instrument. The coding instrument used for collecting data for this study was a content checklist (see Appendix D) designed by the researcher to facilitate the analysis of the 12 sample programmes collected from colleges of education. The validity and reliability of that checklist are discussed in this section.

Validity concerns about data collection schedules, are essentially similar to those raised by any other method of investigation and can be established by having expert opinions on the definitions of categories, units of coding and the rules and procedures for coding. The steps leading to the development of the checklist are described below and it is upon the soundness and appropriateness of this procedure that the claim of validity of the coding instrument used for this study must rest. Besides, the definition of categories and sub-categories (Table 5.1) were rooted in a developed theory arising from the literature review of chapter 3.

However, an assessment of the reliability of data obtained from such a structured schedule has attracted particular specialist approaches. Hence, there are now two kinds of reliability: intra-observer reliability (sometimes called observer or coder consistency) and inter-observer reliability (or inter-observer agreement or reliability of categories).

Observer consistency is the extent to which an observer obtains the same results when measuring the same behaviour on different occasions (e.g. when coding the same training programme at intervals of , say, a week). Inter-observer agreement is the extent to which two or more observers obtain the same results when measuring the same behaviour (e.g. when independently coding the same training programme).

It was possible to establish observer consistency by repeating some coding at a later stage to check that consistency coding was taking place. But as a further check on this

and in order to test inter-observer agreement it was thought necessary to employ some other statistical indices.

Several indices have been developed. They involve the calculation either of the degree of correlation between two sets of measurements obtained with the instrument or of the agreement (sometimes called concordance) between approaches. Martin and Bateson (1986) consider that "an index of concordance need only be used if there is some reason why agreement over each occurrence of the behaviour is an important issue, or if the behaviour is measured on a nominal scale" (p.92). However, Bakeman and Gottman (1986) feel that this kind of agreement is generally valuable. They advocate the use of concordance measure, such as Cohen's Kappa, which correct for chance agreement. There would certainly be advantages for us in this study to compare results obtained by different coders with the same checklist. This way of defining agreement was, therefore, considered to be necessary. It is both simple and rigorous. The validation exercise and reliability study proceeded, therefore, as follows:

First, a list of categories and one training programme, together with the definition of unit of coding were submitted to experienced mathematics teacher educators. These judges were to examine the categories to see whether they represented the elements in the programme, whether they were exhaustive, mutually exclusive and relevant to the study and, above all, to make suggestions where necessary. They were also to examine the suitability of the unit for coding chosen. Appropriate adjustments to category definitions and enumeration system to be used were then made on the basis of suggestions and definitions agreed upon by the judges and the researcher. For instance, the six categories were split into twenty-five sub-categories for easier coding. And the enumeration system was redefined to cater for "recalcitrant" topics - these were topics that did not fit within the units in which they appeared or topics that did not fit within any of the defined categories.

After this, the second step was to design the coding instrument, the checklist, based on the refined definitions and suggestions. Coding was then done by the researcher using this checklist. Also, the checklist together with a copy of a particular programme already coded by the researcher, plus the coding rules and procedure (see section 5.4) were given to a second coder who did his/her own coding. The twelve sets of coding were then compared. It was found that there were some disagreements especially in the identification of sub-categories. The discrepancies arose because some coders were not careful in differentiating between some sub-categories. For instance, topics such as "psychological principles of learning", which should be in sub-category 3.3, were often confused with "psychological principles of mathematics teaching and learning" in sub-category 4.2. Also, sub-categories 3.5 (management skills) and 5.4 (educational administration and planning) were misunderstood and sub-categories 5.2, 5.3 and 5.4 were mixed up.

A column of explanations was, therefore, added to the definition schedule in order to remove the confusion in categorising units by different coders. Also a discussion on the definitions of the categories and sub-categories, the unit of coding and the enumeration system was held with the coders before coding started. After the discussion a second trial coding exercise was carried out. "Confusion matrices" were then constructed for each pair of the twelve programmes coded and the index of agreement (or concordance) and Cohen's Kappa<sup>1</sup> calculated.

Construction of a "confusion matrix" has the advantage that it shows very clearly where the two coders are differing in their judgement. This was valuable because it helped to highlight the initial confusions already discussed. The checklist was consequently

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<sup>1</sup> Appendix F illustrates the computation of an index of concordance ( $P_c$ ) and of Cohen's Kappa ( $K$ ) with simple data. Bakeman & Gottman (1986 pp. 70-99) give an extended discussion with examples and further references.

expanded and refined to include the categories, the sub-categories and, a copy of Table 5.1 The final coding was done with this improved version.

There are ways of assessing the significance of Kappa (K) (see Bakeman and Gottman, 1986, p.80). Fliess (1981), however, suggested the following 'rule of thumb':

$K < 0.40$ .....	poor
$0.40 \leq K < 0.60$ .....	fair
$0.60 \leq K < 0.75$ .....	good
$K \geq 0.75$ .....	excellent

In all instances, the calculated index (or percentage) of agreement ( $P_c$ ) was greater than 87% and K was greater than 0.81 for all pairs of coding compared. Also  $P_c = 89\%$  and  $K = 0.84\%$  when the twelve pairs of coding were taken together. Table 5.4 displays the confusion matrix for programme J which produced the least reliability measure: Kappa (K) = 0.867 for programme J. Table 5.5 is the confusion matrix for all the programmes combined. Thus, the data gathering instrument employed for the content analysis could be taken to have both intra and inter reliability to the extent that similar results were obtained by at least two different coders in each of the 12 pairs of coding carried out.

Table 5.4.. Confusion matrix for Programme J

Categories	Second Coder						Total
	1	2	3	4	5	6	
1	<b>18</b>	2	0	0	0	0	20
2	0	<b>0</b>	0	0	0	0	0
First Coder	3	0	0	<b>11</b>	1	0	12
4	0	0	1	<b>4</b>	0	0	5
5	0	0	1	0	<b>1</b>	0	2
6	0	0	0	0	0	<b>1</b>	1
Total	18	2	13	5	1	1	<b>40</b>

*Index of agreement (or concordance) =  $P_c = 87.5\%$*   
*Kappa (K) = 0.81*

Table 5.5. Cumulative Confusion matrix for ALL Programmes

Categories	Second Coder						Total
	1	2	3	4	5	6	
1	<b>235</b>	17	0	0	0	0	252
2	0	<b>8</b>	0	0	0	0	8
First Coder	3	0	1	<b>116</b>	16	1	134
4	0	0	12	<b>42</b>	1	0	55
5	0	0	2	4	<b>23</b>	0	29
6	0	0	0	0	0	<b>18</b>	18
Total	235	26	130	62	25	18	<b>496</b>

*Index of agreement (or concordance) =  $P_c = 89.1\%$*   
*Kappa (K) = 0.84*



In each of these tables, scores on the leading diagonal from top left to the bottom right (shown emboldened), indicate agreement between the two coders; scores off this diagonal indicate disagreement. The column of totals on the right hand side of each table represent the results of the researcher's coding.

On the whole, there were 363 pages of written documents relating to the material under study across the twelve programmes which were read, recorded and analysed into 496 units of courses and 1271 credit hours distributed across categories as shown in Table 5.6. Table 5.7 is a summary of courses found in programmes for mathematics teacher education in Nigeria.

**TABLE 5.6. DISTRIBUTION OF UNITS ACROSS CATEGORIES**

DIMENSIONS	CATEGORIES	No. OF COURSES (%)	NO. OF CREDIT UNITS	MEAN CREDIT UNITS/COURSE
Subject Matter Knowledge	1. Knowledge of maths	252 (51%)	727 (57%)	2.9
	2. Knowledge about maths	8 (1.6%)	16 (1.3%)	2.00
Pedagogical Knowledge	3. Gen. Ped. Knowledge	134 (27%)	272 (21%)	2.03
	4. Pedagogical Content Kn.	55 (11%)	124 (9.8%)	2.26
	5. Context Knowledge	29 (5.8%)	58 (4.6%)	2.00
Practical Knowledge	6. Practical Experience	18 (3.6%)	72 (5.7%)	4.00
ALL		496 (100%)	1271 (100%)	2.56

Table 5.7. DISTRIBUTION OF COURSES ACROSS PROGRAMME

COURSE TITLES	u <sup>3</sup>	STATUS <sup>2</sup> OF A COURSE IN A PROGRAMME											
		A	B	C	D	E	F	G	H	I	J	K	L
<b>Year One or 100-level courses</b>													
Use of English	2	c	c	c	c	c	c	c	c	c	c	c	c
Philosophy and logic	2	c	c	c	c	c	c	c	c	c	c	c	c
History of Science	2	c	c	c	c	c	c	c	c	c	c	c	c
Nigerian Peoples and culture	2	c	c	c	c	c	c	c	c	c	c	c	c
Basic concepts in mathematics	2	x	c	x	x	x	x	x	x	x	x	x	c
School mathematics contents	2	c	c	c	c	c		x	x	x	x	x	x
Introduction to computers	2	c											
Elementary Algebra and trigonometry	2/3	c	c		c	c							
Introduction to Calculus	3	c											
Everyday Statistics	2						c						c
Theory and practice of education	2/3	c	c	c	c	c	c	c	c	c	c	c	c
History of education	2		c		c	c							
Philosophy of education I	2	c	c	c	c	c	c	c	c	c	c	c	c
Child Development	2	c	c	c	c	c	c	c	c	c	c	c	c
<b>Year Two or 200-level courses</b>													
Linear Algebra I <sup>4</sup>	3												
Linear Algebra II	3						x						x
Abstract Algebra I	3												
Abstract Algebra II	3						x						x
Differential calculus	3												
Vectors and co-ord. geometry	3												
Number theory	3						x						x
Descriptive statistics	3	c	c	c	c	c		c	c	c	c		c
History of mathematics	2			x	x		x		x		x		x
Mathematics methodology I	2/3	c	c	c	c	c	c	c	c	c	c	c	c
Problem solving strategies and Techniques in mathematics	2/3							c		c	c		
Psychology of education I	2	c	c	c	c	c	c	c	c	c	c	c	c
Psychological principles about learning	2												
Philosophy of education I	2	c	c	c	c	c	c	c	c	c	c	c	c
Curriculum studies	2/3	x	x	x	x	x	c	x	c	c	x	c	c
Curriculum and instruction	2/3	c	c		c								c
Class/Group management	2	x	x	x	c	c	x	x	x	x	x	x	x
<b>Year Three or 300-level courses</b>													
Inferential statistics	3			x									
Probability	3												
Real analysis	3												
Vector analysis	3												
Functional analysis	3												
Dynamics and Statics	3												x

<sup>2</sup> "c" = This course is offered and is compulsory. "x" = This course is not offered in this programme. otherwise course is offered but is optional.

<sup>3</sup> Number of credit allocated to a course. [This is not always the same in all programmes; variation is indicated (e.g. 2/3) where it occurs].

<sup>4</sup> In all programmes Part I courses (e.g. Linear Algebra I) are pre-requisites for their Part II components (e.g. Linear Algebra II).

Ordinary differential equations	3													
Finite mathematics	3							x						
Mathematics methodology II	2/3	c	c	c	c	c	c	c	c	c	c	c	c	c
Measurement and testing in mathematics	1/2	x	x	x	x	c	x	c	c	x	c	c	c	c
Measurement and testing in education	2	x	x	x	x	c	x	x	x	x	x	x	x	x
History of mathematics education in Nigeria	2		x	x	x	c	x	x	x	x	x	x	x	x
History of education	2													
History of education in Nigeria	2													
Psychological principles about learning mathematics	2	x					x	x	x	x	x	x	x	x
Educational planning and admin.	2		x		x	x								
Project writing methods	2	x	x	x										
Research methods	2						x					x	x	
<b>(a) Total compulsory courses</b>		17	17	13	17	19	13	14	14	14	14	15	16	
<b>(b) Total optional courses</b>		25	24	27	26	23	24	28	28	28	26	23	27	
<b>Total (a) + (b)</b>		<b>42</b>	<b>41</b>	<b>40</b>	<b>43</b>	<b>46</b>	<b>37</b>	<b>42</b>	<b>42</b>	<b>42</b>	<b>40</b>	<b>38</b>	<b>43</b>	

## 5.7. Findings

In section 5.2 we identified eight types of basic information which together determine the structure of a programme (see Appendix H-2). We also identified three dimensions of teachers' knowledge; defined six categories of a teachers' knowledge and twenty-five sub-categories of knowledge which constitute the syllabus content of programmes for training a mathematics teacher. These are now used to provide a framework for the following commentary under two main headings: programmes structure and training provisions.

### 5.7.1 Programme Structure

Appendix H-2 provide us with information about the structure of the programmes investigated. These are discussed below under the following three headings: entry requirements and the selection process, scheme of studies and evaluation procedures in operation, and certification requirements and intended destination for trainees after training.

(a) *Entry requirements and selection procedures*

Table 5.8 is a summary of the information recorded in columns 2 and 3 of Appendix H-2 which gives details of the entry requirements and selection procedures for admission to each of the twelve programmes analysed.

**TABLE 5.8. SUMMARY OF ENTRY AND SELECTION REQUIREMENTS  
ACROSS PROGRAMMES**

REQUIREMENT	PROGRAMMES											
	A	B	C	D	E	F	G	H	I	J	K	L
Credit (or merit) in mathematics & English.	x	x	x	x	x	x	x	x	x	x	x	x
Additional credit (or merit) in 3 subjects	x				x							
Additional credit (or merit) in one subject		x <sup>1</sup>	x					x		x		x <sup>1</sup>
Interviews before selection		x	x			x		x		x	x	x
Entrance Exam and/or Aptitude test					x	x	x				x	

<sup>1</sup> This must be a science subject. An "x" in a cell indicates a requirement.

From this table it can be seen that in all programmes the stated minimum admission requirement include the possession of a credit (or merit) pass in mathematics and English language. This is to be obtained in any of the Senior School Certificate examination (SSCE), the General Certificate of Education Examination (GCE), the West African School Certificate Examination (WASC) or the Grade Two Teachers Certificate Examination (TC2). These qualifications are considered to be of equal status in Nigeria.

Difference in admission requirement occur in the number of subjects, additional to mathematics and English language, which are asked for at credit (or merit) levels. For example to enter programmes A and E candidates are required to possess 3 credits (or merits) in three additional subjects; for programmes C H and J the requirement is one additional credit (or merits) in any other subject, while programmes B and L stipulate that the one additional subject must be a science subject. Appendix H-2 show, however, that programmes F and K would accept candidates with only two credits or qualifications, other

than those listed in the programme, if considered appropriate by the Head of mathematics department.

There are no restrictions to the number of examination sittings or time limit in which these minimum requirements are to be accumulated.

Selection and admission to courses are largely by qualification and review of application forms. Seven of the twelve programmes, however, interview candidates before final offers are made. Only two programmes (E and G) include entrance examinations or aptitude tests, in addition to the minimum academic entry requirements, as a selection process.

Apart from some entrants to programmes F and K, those entering colleges of education in Nigeria to train as school mathematics teachers could be said to possess similar entry backgrounds in mathematics.

*(b) Scheme of studies and evaluation procedures*

Table 5.9 is a display, in a more concise form, of the information about the duration of training and schemes of studies across programme groups, taken from columns 4, 5, and 6 of Appendix H-2. It is seen from this that all programmes offer full-time training for mathematics teaching. Five of the programmes offer part-time training also. The full-time programmes are for a minimum of three academic sessions and the part-time programmes spread over a period of five years with at least one contact session of 8 to 12 weeks in each academic year.

**TABLE 5.9. SUMMARY OF DURATION/SCHEME OF STUDIES ACROSS PROGRAMMES**

Duration of training or scheme of studies	PROGRAMMES												sum
	A	B	C	D	E	F	G	H	I	J	K	L	
Full-time (6 semesters or 9 terms)	x	x	x	x	x	x	x	x	x	x	x	x	12
Part-time (10 semesters or 15 terms)					x	x		x		x			4
Semester Programmes	x		x	x	x	x	x		x		x		8
Term Programmes		x						x		x		x	4

Most (9) programmes operate the 'semester' system while others (3) operate the 'term' system. In Nigeria one semester is usually 18 weeks long and there are 2 semesters (36 weeks) in one academic session. The remainder of the year (i.e. 16 weeks) is reserved for holidays and private studies. On the other hand one term is 13 weeks long and there are 3 terms (39 weeks) in one academic session; the remaining 13 weeks of the year is also for holidays and private studies.

Also, from column 5 of Appendix H-2 we notice that all programmes operate a scheme of studies which offer their students a choice between modules at some point in the programme. It is also seen (column 6 ) that, except in four cases where the term system are in operation, modules are assessed during the semester in which they are taught. In other cases modules are examined at the end of each term. No programme operate the old end-of-the-year one-off examination that characterised school assessment system in most secondary schools in Nigeria at the time of this research.

*(c) Certification standard and destination after training*

Table 5.10 is a summary of the information in columns 8 and 9 of Appendix H-2. It summarises the minimum standards, in terms of number of credits, required by each programme for NCE certification and the target destination of student teachers after their training, as specified in the programmes.

**TABLE 5.10. SUMMARY OF CERTIFICATION REQUIREMENTS AND TARGET DESTINATION OF TRAINEES AFTER GRADUATION**

Assessment components	Minimum credit required for certification in each assessment component across programmes											
	A	B	C	D	E	F	G	H	I	J	K	L
Modules <sup>5</sup>	72	72 <sup>1</sup>	72	90	90	78	88	88	78	102	102 <sup>2</sup>	72 <sup>1</sup>
Teaching Practice	6	6	6	6	6	6	6	6	6	6	6	6
Projects	4	4	4	4	4	4	4	4	4	4	4	4
<b>Total minimum credit</b>	<b>82</b>	<b>82</b>	<b>82</b>	<b>100</b>	<b>100</b>	<b>88</b>	<b>98</b>	<b>98</b>	<b>88</b>	<b>112</b>	<b>112</b>	<b>82</b>
Minimum number (%) of credits from subject matter component <sup>4</sup>	36 50%	36 50%	36 50%	28 33%	28 33%	20 25%	30 33%	30 33%	26 25%	26 25%	23 25%	36 50%
Maximum number (%) of credits from education coursework <sup>6</sup>	36 50%	36 50%	36 50%	62 70%	62 70%	58 75%	58 66%	58 66%	52 67%	76 75%	67 75%	36 50%
Target destination of students <sup>3</sup>	p/s	p/s	p/s	s	s	p/s	s	p/s	s	p/s	p/s	p/s

Explanations to entries in Table 4.11.

- <sup>1</sup> This must be made up of 8 credits from General Studies (GS) courses, 16 credits from first year or 100 level courses and 48 credits from 200 and 300 level courses.
- <sup>2</sup> Candidates with TC2/GCE/SSC require 78 credits; those with lower entry qualifications require 112 credits, while those with 'A' level or equivalent qualifications at entry require only 62 credits from specified courses.
- <sup>3</sup> p = primary school.; s = Junior secondary school.
- <sup>4</sup> Including all compulsory mathematics courses but excluding mathematics methodology courses which are regarded as education courses.
- <sup>5</sup> Including 8 compulsory credits from all four General Studies courses.
- <sup>6</sup> Must include credits for all compulsory education courses excluding Teaching practice and project credits.

From this table, it is seen that eight programmes stated that they prepared students for teaching mathematics at the primary and junior secondary levels (ages 6-12 and 12-14 respectively). Only four programmes prepare student teachers strictly for the junior secondary school level.

Also the Nigerian Certificate in Education (NCE) in mathematics is awarded to candidates who obtained a total credit units ranging from 82 to 112. These include six credits for

successfully completing the teaching practice exercise, four, for project and the remaining credits are to be earned from courses in mathematics or education. The weight accorded to each of the last two components vary from programme to programme and range between 25% and 50% for mathematics courses and 50% and 75% for education courses.

### **5.7.2. Curricular Provisions**

This study also set out to collect information on what, in real terms, students undergoing training for mathematics teaching at the colleges of education went through or were being exposed to in the course of their training.

Tables 5.2 and 5.3 are summaries, in coded form, of information on training provisions in the twelve programmes. Table 5.3, for instance, shows details of:

- 1) the number of courses in a category and sub-category offered by a training programme;
- 2) the number of credits allocated to a category or sub-category in each training programme.

What follows is a highlight of the information that can be discerned from the data of those two tables.

Table 5.2 shows that there are differences (apart from those already highlighted in the preceding section) among the twelve training programmes, in the manner in which they chose to provide for and distribute modules/courses in the six categories. We shall now proceed to discuss these differences category by category.

#### *Category 1: Knowledge of mathematics*

Two sub-categories (school mathematics content and non-school mathematics content) were identified in this category. Table 5.2 shows that seven of the twelve programmes provide opportunities for trainees to take at least a course in the contents of the Nigerian National Mathematics Curriculum (NNMC) as recommended by the National Commission for



Colleges of Education (NCCE). Out of these, five programmes offered three courses of two credits each on school mathematics content; the remaining two programmes offered just one course of two credits each. Five programmes (F, G, H, I and J) did not offer courses dealing with school mathematics contents. That was in spite of the NCCE, recommendations.

Table 5.7 shows that apart from the secondary mathematics content courses, which are compulsory where they are offered, trainees are free to choose the mathematics courses they study during training. Restriction seemed to come in the form of prerequisites for courses and in the number of available courses in a particular level and, presumably, in time-tabling.

*Category 2. Knowledge about mathematics*

This category is largely ignored by all programmes. For instance, no programme offers courses that could possibly be classified as providing for knowledge about the nature of mathematics or beliefs about mathematics as defined in the content analysis schedule of Table 5.1. Only one programme offer one 2-credits course on the purpose of mathematics. Seven programmes (that is just over 58%) offer one 2-credits course on the history of mathematics. In all, only eight (approximately 1.6%) of the total courses on offer in all twelve programmes, accounting for a total of 16 credit hours, are allocated to this category. Put another way, the proportion of actual contact time devoted to exposing student teachers to knowledge about the subject matter of their discipline to the time available for the entire preparation of the trainee in all programmes is less than 2%. The impression one discerns from this is that designers of mathematics teacher training programmes in Nigeria appear not to have attached much importance to this domain of the teachers' knowledge in their choice of courses to include. This is both interesting and surprising bearing in mind the views of research about the possible effect of inadequate knowledge of subject matter to teacher confidence.

*Category 3: General pedagogical knowledge*

Seven sub-categories were identified and defined in this category. Data from Tables 5.2, 5.3 and 5.7 show this category, except for management skills, to be well provided for in all programmes. The number of courses and credits allocated to the courses, in this category, range from nine 2-credits courses in programme A to fourteen 2-credits courses in programme D. This accounts for over one-quarter (about 27%) of the total number of courses on offer in all programmes or 21% of the total contact hours allotted for the training. Two programmes (D and E), only, offer a course each in management skills. This is, probably, because NCE teachers are not expected to be promoted, without further training, to a level in the teaching profession where management skills would be required.

*Category 4: Pedagogical content knowledge*

Two very important sub-categories of this category of contents are ignored by many programmes. These are 4.2 (psychological principles of mathematics teaching and learning) and 4.4 (Assessment and evaluation skills in mathematics). Only four programmes (A, C, D and E) provide courses in sub-category 4.2 and only 6 programmes (E, G, H, J, K and L) bothered to provide mathematics teachers with assessment and evaluation skills in their subject area. This is something that should be of concern to mathematics educators in any context. Teachers' activities in the school setting are largely concerned with assessing and evaluating various components of the curriculum and/or their students. For a programme geared towards their preparation to ignore this is surprising, to say the least.

*Category 5: Context knowledge*

Only two of the four sub-categories of this category are provided for in any of the programmes. These are sub-category 5.1 (Nigerian Peoples and Culture) and 5.4 (Educational Administration and Planning). The first of these is part of what constitute the General Studies Courses (GS) recommended in the National Policy and defined precisely in the NCCE's (1990) guideline document, referred to earlier.

None of the programmes offer any courses in school governance or school financing. This, again, is probably because this level of teachers are not expected to be promoted, without further training, to a position where they will be faced with duties requiring these knowledge or skills. This is, however, not made certain from the information discerned from the documents.

*Category 6: Practical Skills*

Column 7 of Appendix H-2 and Table 5.2 both show three models of practical teaching arrangements. The first, in programmes A, B, C, E, G, and L, is a two-six-weeks long teaching practice in a secondary school; usually in the fourth or sixth semester (or sixth and eighth term) of training. The second is a one-off twelve-weeks long teaching practice in a secondary school in the last semester of training. These were for programmes D and K. Finally, the third, programmes F, H, I and J, is a school-based model of one academic year duration; usually the last year of training, to be spent attached to an experienced mathematics teacher (a mentor - although the term "external supervisor" instead of mentor is used in Nigeria) in a secondary school. A report on the student teacher, from the external supervisor in conjunction with the report of the internal supervisor (usually a lecturer from the college of education), is then used for final assessment of practical competence. One thing that is not, however, clear from the data is the criteria applied in allocating credits to the teaching practice exercise in different programmes. For instance, all programmes assign six credits to the practical teaching component although duration differ; ranging from 12 weeks to 36 weeks. It appeared, however, from arrangements of courses in the programmes for the final year, that students teachers in the school based model still took courses in their respective colleges at the same time as they were carrying out the teaching practice exercise.

### 5.8. Summary

In this chapter we set out to determine trends in in-service education of school mathematics teachers in Nigeria and to find out if there were any differences in the activities and experiences provided for trainees in the variety of programmes that existed in the 53 colleges of education in that country. Twelve training programmes were chosen at random and their contents were analysed.

The analysis revealed that:

1. To train as a school mathematics teacher in Nigeria, entrants to colleges of education are expected to have obtained a minimum entry qualification equivalent to two C-grade passes in GCSE in mathematics and English language; plus C-grade passes in at least one other subject, preferably a science. Two colleges accepted other qualifications provided that these are considered adequate by the head of mathematics department in the college.
2. Final offers for training in colleges of education depend, in general, on review of the application forms and/or an interview. Entrance examinations or aptitude tests are rarely used as an admission process.
3. Approximately two-thirds of colleges of education in Nigeria, operate the two-semester in one academic year system. The remaining one-third operate the three-terms in a year system. All colleges offer full-time training programmes lasting 3 years (6 semesters or 9 terms). About one in three also offer part-time training for 10 semesters or 15 terms.
4. At the end of training the Nigeria Certificate in Education (NCE) in mathematics is awarded to trainees who accumulate enough credits (ranging from 82 to 112), successfully complete a practical teaching exercise in a secondary school (ranging from 12 to 36 weeks) and submit an approved project in a topic in mathematics or mathematics education. The proportion of the total number of credits between subject matter component and pedagogical component required for certification differ between programmes. This appear to depend on

the importance attached to a component by the trainers in a college and/or the validating university.

5. Training packages include courses, activities and experiences designed to inculcate some desirable mathematics teacher knowledge and skills. Some knowledge components, identified by research as likely to enhance for good mathematics teaching, are either totally ignored or glossed over by some training programmes. For instance, majority of programmes seem to concentrate their effort in teaching non-school mathematics content (e.g. higher education and university level mathematics) rather than on school mathematics content and methods of teaching which their intakes (trainees) probably needed. Also pedagogical content knowledge (e.g. teaching methods and approaches for school mathematics topics), the one domain of knowledge unique to the teaching profession, and which distinguishes mathematics teachers from other content specialists such as theoretical mathematicians, appears to have been given minimal attention.

6. In particular, evaluation and assessment skills in mathematics, management skills and knowledge about mathematics (e.g. purpose, nature or history of mathematics) are the three sub-components of essential teacher knowledge that are inadequately provided for in all the programmes.

7. Finally, the general impression gained, from analysing the sampled teacher education programmes seem to be that training curricula and school mathematics curriculum, in Nigeria, are not wholly related. Evidence from the analysis of data generated by the SMCT in chapter 6 also seem to support this observation.

## CHAPTER 6

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### ANALYSIS OF SCHOOL MATHEMATICS CONTENTS TEST (SMCT) SCORES

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#### 6.1. Introduction

In the preceding chapter we employed the method of content analysis in order to answer the first three of the six guiding questions of this research. The next two questions concerned the relevance of the training programmes to the subject matter<sup>1</sup> of the Nigerian National Mathematics Curriculum (NNMC). The questions were about the relationship between two variables: training programmes and the level of understanding of school mathematics subject matter of student teachers after training. For convenience the two questions are restated here. They are:

**Question 4.** What level of understanding of school mathematics subject matter in Nigeria do student teachers possess at the terminal point of training as their basis for teaching the NNMC? In other words, how well do student teachers understand the syllabus which they are to start teaching in a few weeks?

**Question 5.** Are there any differences at graduation in the level of understanding of subject matter by student teachers passing out from different colleges of education in Nigeria? In other words, does the level of

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<sup>1</sup> The *subject matter* of a curriculum consists of the key facts, concepts, principles and explanatory frameworks in the discipline, known as *substantive knowledge*, as well as the rules of evidence and proof within that discipline, known as *syntactic knowledge*. In mathematics, substantive knowledge includes mathematical facts, concepts and computational algorithms; syntactic knowledge encompasses an understanding of the methods of mathematical proof and other forms of argument used by mathematicians (see also Chapter 3 - Literature Review).

understanding of subject matter by student teachers depend on the programme under which they were trained?

Data for answering these questions were collected using the school mathematics content test (SMCT). See Appendices C and H-1

The goal of this chapter is to present the analysis of the data generated with the SMCT. In section 6.2, we describe the structure, content, validity and reliability of the test instrument (the SMCT). In section 6.3, we explain the criteria that were applied in this study to reach a decision on the question of student teachers' level of understanding of school mathematics subject matter. And in section 6.4, we present the relevant statistical procedures employed in analysing the data. Finally, section 6.5 is a summary of the results of the analysis presented in this chapter.

## **6.2. The test instrument**

### **6.2.1. Structure and content**

The instrument used in this study for measuring student teachers' level of understanding of school mathematics subject matter, is the School Mathematics Contents Test (SMCT)<sup>2</sup>. The SMCT contained 100 4-choice multiple-choice items limited entirely to the four major content areas of the NNMC: number and numeration, algebra, geometry and trigonometry, and basic statistics. The items were further grouped according to three behaviours, identified by research, which a mathematics teacher should be able to exhibit at graduation: general and definitional knowledge, process skills, and problem

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<sup>2</sup> The steps leading to the construction of the SMCT were described fully in section 3.4.1. of Chapter 3. What is presented here is a summary of parts of that description which are relevant to the analysis presented in this chapter.

solving and application skills. These behaviours were explained and defined for this study in section 4.4.1 (page 90) of chapter 4 (see also Table 4.4).

Thirteen bad items among the original 100 items of the SMCT were later discarded for reasons already explained in section 4.5.1 ( see pp 95-97). The distribution of test items in the corrected version of the SMCT, according to the content areas and behaviour levels is displayed in Table 6.1. This table was extracted from Table 4.6 (page 97) by discarding 13 of the 100 items in the initial test. The distribution of the discarded test items across content areas and behavioural levels is shown in Table 6.2.

**Table 6.1. DISTRIBUTION OF 87 TEST ITEMS OF THE CORRECTED SMCT  
(content areas by behavioural levels)**

Behaviour Levels ↓	Content Areas								Total
	Number and Numeration NN		Algebra ALG		Geom. & Trig GEOT		Basic Stats STAT		
	Item Nos.	Total	Item Nos.	Total	Item Nos.	Total			
Definitional and General Knowledge (DGK)	1, 5, 6, 9, 10, 11, 12.	7	36, 37, 71	3	45, 47, 48, 50, 61, 63, 80, 81, 84, 85, 89	11	64, 66, 67	3	24
Process Skills (PS)	3, 4, 7, 8, 13, 14, 15, 16, 17, 18, 20, 21, 26, 27, 43, 53, 54, 61, 69, 70, 72, 74, 87, 91, 92, 98,	26	23, 24, 31, 32, 34, 35, 39, 42, 44, 68, 73, 75, 76, 77, 90, 93, 95.	17	49, 51, 52, 55, 56, 58, 59, 60, 79, 82, 96, 97, 99, 100	14	65	1	58
<b>Totals</b>		<b>33</b>		<b>20</b>		<b>25</b>		<b>4</b>	<b>82</b>
Problem Solving and Application Skills (PsAS)	2, 20, 22, 29, 30, 43, 60, 72, 83, 94,								10
<b>TOTAL</b>									<b>92*</b>

\* Five items (viz.: 20, 43, 60, 61, and 72) appear in more than one group. The total number of items in the CORRECTED test is 87.



Table 6.2. DISTRIBUTION OF THE 13 DISCARDED ITEMS OF THE SMCT

	NN	ALG	GEOT	STAT	TOTAL
DGK	1	1	2	0	4
PS	1	3	5	0	9
PsAS	0	0	0	0	0
TOTAL	2	4	7	0	13

From Table 6.2 it is seen that the number of discarded items ranged from 2 out of 35 (approx. 6%) in the number and numeration content area to 7 out of 32 (22%) in geometry and trigonometry. Also 4 (about 17%) of the 24 items dealing with algebra were discarded.

If behavioural levels were the focus of interest, the range of discarded items was from 4 out of 28 (approx. 14%) in definitional and general knowledge to 9 out of 67 (13%) in process skill; no items dealing with problem solving and application skills were discarded.

It was thought that these changes might have disturbed the original weighting (in terms of the number of objectives and average time spent on each topic) of the different constituent areas which was meant to reflect the relative importance of each of the areas. For instance the number of items in NN, ALG, GEOT and STAT occurred, respectively, in the ratio 35:24:32:4 in the original test. In the corrected test their distribution was in the ratio 33; 20:25:4. Are the differences between the original and corrected frequencies significant?

Chi-square procedure was then applied to see if by discarding the 13 test items the weighting of the content areas, as initially conceived, had been significantly altered; in other words, whether the distribution of test items in the corrected version was different from their distribution in the initial version.

The first row of Table 6.3 shows the observed (*O*) number of items in each of the four content areas of the corrected test. The second row contains the expected (*E*)

frequencies under  $H_0$  (the number of items in the content areas occur, as originally conceived, in the ratio 35:34:32:4). The expected frequencies were obtained from:

$$E_i = \frac{R_i}{95}(82)$$

where,  $R_i$  is the share of a content area,  $i$ , in the distribution of items in the corrected test

and  $i = (\text{NN, ALG, GEOT, and STAT})$ . For example  $E_{\text{NN}} = \frac{35}{95}(82) = 30.2$ , and so

on.

**Table 6.3. ACTUAL (O) AND EXPECTED (E) DISTRIBUTION OF TEST ITEMS IN THE SMCT**

	NN	ALG	GEOT	STAT	TOTAL
Observed number of items (O)	33	20	25	4	82
Expected frequencies under $H_0$ (E)	30.2	20.7	27.6	3.5	82

From Table 6.3 the estimated<sup>3</sup>  $\chi^2$  (= 1.243) was less than  $\chi^2_{3(95\%)} (=7.815)$ . This means that one was about 95% sure that the difference between original and corrected versions of the test, in terms of the weighting given to different constituent areas, is not significant. It was, thus, thought reasonable to assume that the relative weighting given to the different constituent areas has not significantly changed.

However, the fact still remains that the validity of the test and, thus, the outcome of this analysis might have been affected by the changes; since certain specific contents of the NNMC which were intended to be tested by the 13 discarded items were left out in the corrected test. It is hoped, in any case, that the advantage of using multiple methods of data collection in this study, which permits triangulation in interpreting results, will help us to get a better estimate of "the answers" to the specific questions of this research.

<sup>3</sup> Other contingency tables and  $\chi^2$  calculations related to Chi-square tests in this chapter are attached as Appendix G

The SMCT was used to investigate student teachers' level of understanding of school mathematics subject matter in the four content areas of the NNMC and to identify which desired teacher behaviours were not adequately enhanced during training.

The test was administered to 265 student teachers, chosen randomly from the 53 colleges of education in Nigeria, at the terminal point of their training. It required the respondents to check the right answer to each of the 100 items. The test items were not weighted and, therefore, a score of 1 (one) point or mark was credited to a student teacher for every item got right and a score of 0 (zero) was credited for a wrong answer or an omission.

The feature of respondents (student teachers) measured with the SMCT was their ability to demonstrate competence in the subject matter of the NNMC; that is, their level of understanding of the mathematics content of the syllabus which they were expected to teach after graduation. Respondents' levels of competence were then measured by their aggregate scores on the SMCT (here designated as their "performance"). A respondent's performance was later compared with a set criterion in order to determine his/her level of understanding of (or competence in ) the subject matter of the NNMC. Proportions of competent student teachers was then used to investigate variations between programme groups and the relationship between training programmes and levels of understanding of school mathematics subject matter. This procedure allowed us to answer the two specific questions listed earlier at the beginning of this chapter.

However, in interpreting the results of this analysis one must take into consideration the validity and the reliability of the instrument of measurement. A discussion of the validity and the reliability of the SMCT is, therefore, presented next.

### **6.2.2. Validity**

The validity of a test concerns what is being tested, and whether it is tested appropriately. A test is valid to the extent that it does indeed measure what it attempts to measure. In order to ensure the validity of a test, it is necessary to define the content of what is being assessed. In this sense, the content refers not only to the subject matter, but to the behaviour by which mastery of the subject matter is to be demonstrated. Usually, syllabus objectives define both of these clearly. The steps taken to construct the SMCT included a clear definition of both the subject matter of the NNMC and the behaviour, in terms of item objectives, by which mastery was to be demonstrated. These steps were described in detail in section 4.4.1 of chapter 4 and it was upon the soundness and appropriateness of the procedure adopted that the claim for the validity of the SMCT rested.

However, as pointed out earlier, the validity of the SMCT was, perhaps, reduced after the corrections effected on it by discarding 13 of the original 100 test items. The result of the analysis presented in the preceding section (see section 6.2.1 of this chapter) suggests that the overall balance and weighting of the test has not been changed significantly and that, therefore, the validity of the test is not adversely reduced to invalidate the results obtained. What the reader needs to bear in mind is that, whatever the degree of validity assumed, the results of this study (and, indeed, similar studies) must be seen as only indicative and supportive.

### **6.2.3. Reliability**

Results of a test provide information about its reliability, the consistency with which it measures. Reliability information is usually summarised in a reliability coefficient. There are several techniques for estimating reliability coefficients. The most

### 6.2.3. Reliability

Results of a test provide information about its reliability, the consistency with which it measures. Reliability information is usually summarised in a reliability coefficient. There are several techniques for estimating reliability coefficients. The most straightforward is called test-retest reliability, and involves administering the test twice to the same group of respondents, with an interval between the two administrations of, say, one week. This would yield two measures for each person, the score on the first occasion and the score on the second occasion. A Pearson product-moment correlation coefficient calculated on these data would give us a reliability coefficient directly. But although this method is the most straightforward, there are many circumstances in which it is inappropriate. For instance, the SMCT used in the present study is a knowledge-based test and involves some calculation in order to arrive at the answer. For such tests, it is very likely that skills learned on the first administration will transfer to the second, so that tasks on the two occasions are not really equivalent. Differences in motivation and memory may also affect the results. A respondent's approach to a test is often completely different on a second administration (e.g. they might be bored, or less anxious).

A technique, which at first appeared appropriate for our purpose is the parallel forms method. Here we have not one version of the test but two versions linked in a systematic manner. For each cell in the test specification two alternative sets of items are generated, which are intended to measure the same construct but which are different (e.g.,  $2 + 7$  in the first version of an arithmetic test, and  $3 + 6$  in the second). Two tests constructed in this way are said to be parallel. To obtain the parallel forms reliability, each person is given both versions of the test to complete, and we obtain the

reliability by calculating the Pearson product-moment correlation coefficient between the scores for the two forms.

Many consider the parallel forms to be the best reliability measure; however, there are pragmatic reasons why it was not used in this study. For a start, when a test is constructed our main aim is to obtain the best possible items, and if we wish to develop parallel forms not only is there twice the amount of work, but there is also the possibility of obtaining a better test by taking the better items from each and combining them into a "superior test". This is generally a more desirable outcome, and frequently where parallel forms have been generated in the initial life of a test, they have later been combined in this way, as for example in the later version of the Stanford-Binet. For these reasons an alternative technique for estimating the reliability of the SMCT was sought.

The technique considered most appropriate and used in this study was the split-half method. This is because, apart from relating in particular to objective tests (i.e. tests in which the scoring is completely objective), the split-half method, although a sort of pseudo-parallel form, contains no systematic bias in the way in which items from the two forms are distributed with respect to the specification.

For instance, in the present study, the 87 items of the corrected version of the SMCT were divided into two by pooling odd-numbered items for one score and even-numbered items for another score. The odd-even splitting meant that two scores were obtained for each of the 265 student teachers tested, one on the odd-numbered and the other on the even-numbered items (see Appendix I-2). The agreement between these two scores on the same test as determined by Pearson's correlation coefficient was then taken to be a measure of the reliability of a half-length test. The correlation coefficient ( $r$ ) between the two half-lengths of the SMCT was approximately 0.71.

The reliability of the whole test was obtained by applying the Spearman-Brown prophecy formula, for estimating the reliability of a whole test from that of its two halves. The technique requires the substitution of the calculated reliability of the half test (in this case 0.71) in the following equation in order to estimate the reliability of the whole test.

$$r_s = \frac{2r}{1+r},$$

where  $r_s$  is the estimated reliability of the full-length test, and  $r$  is the calculated correlation between the two half-lengths into which the test was split.

Thus, the reliability coefficient ( $r_s$ ) of the full-length SMCT was estimated to be,

$$r_s = \frac{2(0.71)}{1+0.71} = 0.83$$

This is larger than the calculated reliability of the half-length test because the reliability of tests depends upon the number of functioning items they contain; hence the reliability of a half test is lower than that of the whole. The longer of the half tests contains only 44 odd-numbered items while the full-length test contains 87 items.

Reliability coefficients, in general, fall between the limits 00.00 and 1.00. The more reliable a test, the closer the reliability coefficient will be to 1.00. On standardised achievement tests reliability coefficients are, generally, found to be somewhat above 0.75, many being above 0.90. [Thorndike & Hagen, 1977 fourth edition].

From this estimate of the reliability we may derive an estimate of the (average) standard error of measurement (*sem*) given by

$$\text{sem} \equiv s \sqrt{(1-r)}$$

where  $s$  is the standard deviation of test scores and  $r$  is the reliability coefficient of the test.

For the SMCT used in this study,

$$sem = (6.8)\sqrt{1-0.83} \cong 2.8,$$

where 6.8 is the standard deviation of the test scores taken from Table 6.4 below.

If we assume that errors of measurement are normally distributed, this implies that one was about 95% confident that students' obtained scores on the SMCT were no more than  $\pm 5.5$  (that is 1.96 sem) from their true scores. This meant that the true level of performance of a student teacher who scored  $\frac{70}{87}$  (or 80%) on the SMCT lay between the interval  $\frac{64.5}{87}$  and

$\frac{75.5}{87}$  (or 74% and 87%) - that is to say  $80\% \pm 7\%$ . The criteria for making a decision on

student teachers' level of understanding of school mathematics subject matter were defined with this interval in mind. For this reason the interpretation of the results of this analysis was treated with caution.

The reliability coefficients of the sub-tests on the constituent areas of both behaviour and content were similarly estimated. Table 6.4. shows the results of these estimates. The reliability of the STAT component, with only 4 items, was not estimated since that will be meaningless. It was thought more profitable to look, instead, in detail at the four questions (see section 6.4.4).

**Table 6.4. ESTIMATES OF RELIABILITY COEFFICIENTS FOR THE SMCT AND ITS SUB-TESTS**

ESTIMATES ↓	CONTENTS				BEHAVIOURS		
	SMCT	NN	GEOT	ALG	DGK	PS	PsAS
r (reliability of half test)	0.71	0.5	0.5	0.4	0.9	0.63	0.1
r <sub>s</sub> (reliability of whole test)	0.83	0.7	0.7	0.6	0.95	0.77	0.2
sd (standard deviation)	6.8	3	3	2	3	4	1
sem	3.7	2.1	2.1	1.55	0.95	2.4	0.95

From Table 6.4 it is seen that the estimated reliability of the sub-tests are (except for PsAS) reasonable and (except for DGK) lower than that obtained for the whole test. This is not surprising because, as pointed out earlier, the reliability of tests depends upon the number of functioning items they contain. This must, also, account for the very low reliability obtained for the PsAS sub-test. This sub-test contained only 10 items - that is, only approximately 9



percent of the items in of the SMCT dealt with PsAS. Besides, the reliability coefficients are based on arbitrary splitting of each of the tests into two-halves. Clearly, if one half of a short sub-test contains an item which is aberrant, this will lower the apparently reliability of that sub-test. However, again, for this reason more care should be and was taken in interpreting the results of this analysis.

### **6.3. Definition of criteria for competence**

Two criteria were adopted in making decisions about competence:

- (i) performance levels; and
- (ii) differences in the averages of scores.

It is realised that there are some uncertainties about each of these. For instance, performance levels set by a researcher depend largely on the researcher's personal opinion, beliefs and biases and are, therefore, bound to be subjective. They are, thus, unreliable as comparative measures. On the other hand, an unexpectedly extreme score (or outlier), in either direction, in a group is sure to influence the group mean unduly. So that the mean, although a good comparative measure, could, in certain circumstances, give a wrong impression.

Applied separately both criteria have limitations. However, used together, their limitations are reduced because they supplement each other. For this reason, it was decided to use performance levels to determine student teachers' levels of understanding of (or competence in) content and to use the chi-square procedure, on number (proportions) of competent student teachers, to investigate whether there were *prima facie* differences between programmes. Tukey's method was then used to compare differences in averages of scores in order to investigate differences in outcomes between programmes.

When a test instrument is designed to measure mastery of the basic essentials in an area and the questions (or items) are limited to those essentials (as was the case with the SMCT used for this study), one expects that, if the area has been well learnt by a group of students, all the items should turn out to be very easy for the group. In such a test, it is reasonable to expect to have perfect or near perfect scores for most students, with only a few of the students, or none, missing any given item. Mastery tests designed thus could, therefore, be relied upon to give the desired information; that the students have or have not indeed learnt the essentials in the area. The question, however, is what level of achievement is to be accepted as signifying mastery?

Thorndike and Hagen (1977 pp. 215-216) gave a guide of 74% correct responses, on a mastery test made up of 4-choice multiple-choice items, for deciding mastery (or competence). In other words, if as was the case with the SMCT, a mastery test is made up of 87 4-choice multiple-choice items on the subject matter of a particular syllabus and is administered to a group of students who have studied the syllabus, one would expect at least a score of  $0.74 \times 87$  (or approximately 64 out of 87) correct responses as a minimal level for mastery. One's decisions on the levels of achievement among such group would then be based on a consideration of this minimal expectation. Thorndike and Hagen claim that this percentage allows for the possibility of getting right answers by guessing, and for the typical finding that very difficult items are often ambiguous and non-discriminating as between the more and the less able students. They then went on to explain that the percentage they suggest will tend to yield a set of test scores that will be maximally useful to a test maker who wants to discriminate levels of achievement among students.

The SMCT, used for this study, contained 87 4-choice multiple-choice items limited entirely on the subject matter of the NNMC but was administered, instead, to 265

student teachers (not their pupils) at the terminal point of their training. These student teachers were at the point of passing out (in a few weeks time) from training to take up positions as mathematics teachers to teach the NNMC. One would, therefore, expect them to exhibit a higher level of understanding of subject matter of the NNMC than is recommended by Thorndike et al for pupils. For example, a score of, say, 80% or above (i.e. 70 or more correct responses out of 87) in the SMCT would be a reasonable expectation of level of achievement to be accepted as signifying mastery. The following criteria were, therefore, defined and adopted based on Thorndike and Hagen's recommendation and the sense implicit in the above reasoning.

(a) A student teacher was taken to have demonstrated a level of understanding acceptable as signifying mastery of, or competent in the subject matter of the NNMC or in a content area of the NNMC or in one of the three behavioural skills measured in this study, if he/she achieved a set performance level.

(b) If a pre-determined percentage of student teachers, exposed to a particular training programme, demonstrated competence (by achieving the set performance level), the answer to the question about the relevance of the mathematics content of that particular training programme to the school mathematics curriculum in Nigeria was taken to be in the affirmative (YES).

For the analysis presented in this chapter, the set performance level was 80%. This meant that student teachers must have circled at least 70 out of the 87 correct responses to the items in the whole test or 80% of those items allocated to the content area or behaviour levels, as the case may be, in order to be declared "competent" in school mathematics subject matter or to be said to have achieved a minimal level of understanding of the subject matter of school mathematics in Nigeria, or of an area of the NNMC or of any of the behavioural skills.

Also, it was thought that the least percentage of their intakes one would expect, as an output of "competent" student teachers from a training programme, for an affirmative answer to the question about the relationship of the training curricula to school mathematics and the needs of trainees is 80%. The percentage for a "yes" answer to questions 3 and 6 was, therefore, set at 80%.

#### **6.4. Analysis of scores**

##### **6.4.1. Difficult topics/concepts**

A measure of difficulty for each item was first computed and used to identify mathematics concepts/topics which student teachers trained under different programmes found difficult to cope with. The type of analysis employed in this computation was difficulty analysis. It consisted of finding the percentage of student teachers who made the correct response to an item. The nearer this value was to 100, the easier the item was thought to be for the student teachers. A percentage value which was less than 50% was regarded as indicating a difficult item. This cut-off point was considered adequate because it was reasonable to expect that, notwithstanding other factors which can affect performances (e.g. the nature of the test, item construction, wording etc.) at least 50% of teachers should respond correctly to a test item that was based on an area of the school mathematics curriculum. Nine difficult items were identified in this way. They were, in ascending degree of difficulty, items 99, 100, 48, 26, 45, 72, 79, 93, and 81.

Out of these nine difficult items, six dealt with geometry and trigonometry. Three of these six involved definitional and general knowledge in geometry and trigonometry. Also six of the nine difficult items involved the demonstration of process skill across all three content areas. Half of these were, again, items dealing with geometry and

trigonometry. In general, it appeared that student teachers had difficulty responding correctly to items on geometry and trigonometry and those requiring process skill. This result seem to be confirmed by the result of the analysis in section 6.4.2. below. This is dealt with in our discussion in chapter 8.

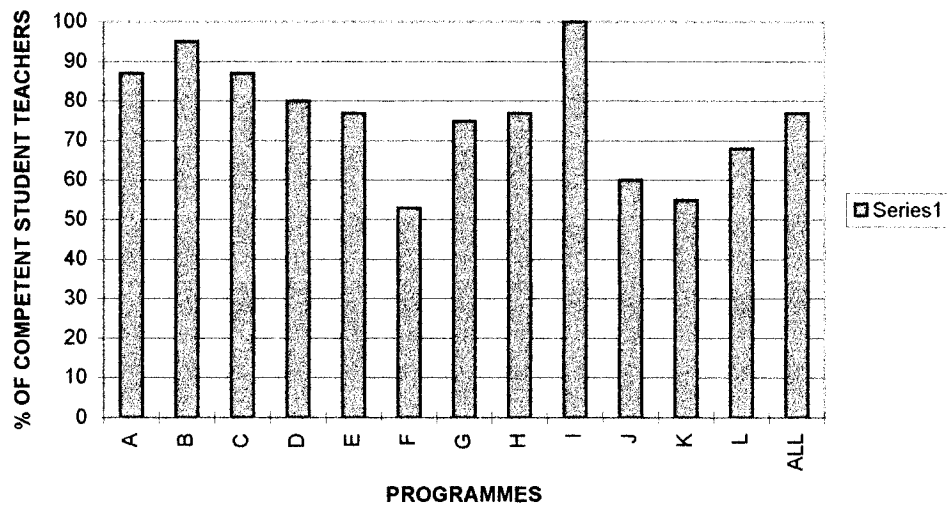
#### 6.4.2. Levels of understanding of school mathematics subject matter

On the basis of the criteria defined in section 6.3, the numbers (and percentages) of student teachers declared competent in each programme group were found and tabulated as shown in Tables 6.5. (As pointed out earlier and for reasons already given in the preceding section, this analysis used the 80% performance level as cut-off point for decision making on competence. The 85% performance level is shown in Table 6.5 for illustrative purposes only.) Figures 6.1 is a representations of the same information at 80% performance level in pictorial form.

**Table 6.5. NUMBER AND PERCENTAGE OF COMPETENT STUDENT TEACHERS ACCORDING TO THREE PERFORMANCE LEVELS ACROSS PROGRAMMES**

Prog Group	No of subjects tested	Number (percentage) of Competent subjects	
		80% level	85% level
A	15	13 (87%)	9 (60%)
B	20	19 (95%)	12 (60%)
C	15	13 (87%)	10 (67%)
D	10	8 (80%)	7 (70%)
E	30	23 (77%)	16 (53%)
F	70	37(53%)	21 (30%)
G	20	15 (75%)	11 (55%)
H	30	23 (77%)	14 (47%)
I	5	5 (100%)	1 (20%)
J	5	3 (60%)	2 (40%)
K	20	11 (55%)	4 (20%)
L	25	17 (68%)	12 (48%)
<b>ALL</b>	<b>265</b>	<b>187 (71%)</b>	<b>119 (45%)</b>

**Figure 6.1 PERCENTAGE OF COMPETENT STUDENT TEACHERS AT THE 80% PERFORMANCE LEVEL ACROSS PROGRAMMES**



Tables 6.6 and 6.7 show, respectively, the number (percentage) of student teachers in each of the programme groups who were declared competent in each of the three content areas of the NNMC and in their ability to demonstrate each of the three behaviour skills tested in this study.

**Table 6.6. NUMBER (PERCENTAGE) OF COMPETENT STUDENTS TEACHERS AT 80% PERFORMANCE LEVELS ACROSS PROGRAMMES BY CONTENT AREAS OF THE NNMC**

PROG	No. of subjects tested	Number and Numeration (NN)	Geometry and Trigonometry (GEOT)	Algebra (ALG)
A	15	11 (73%)	5 (33%)	14 (93%)
B	20	15 (75%)	3 (15%)	19 (95%)
C	15	12 (80%)	8 (53%)	14 (93%)
D	10	8 (80%)	4 (40%)	8 (80%)
E	30	25 (83%)	6 (20%)	25 (83%)
F	70	50 (71%)	8 (11%)	54 (77%)
G	20	19 (95%)	3 (15%)	17 (85%)
H	30	19 (63%)	3 (10%)	24 (80%)
I	5	4 (80%)	0(0%)	4 (80%)
J	5	3 (60%)	0 (0%)	5 (100%)
K	20	10 (50%)	0 (0%)	13 (65%)
L	25	20 (80%)	3 (12%)	18 (72%)
<b>ALL</b>	<b>265</b>	<b>196 (74%)</b>	<b>43 (16%)</b>	<b>215 (81%)</b>
mean score		27	18	17
mode		28	19	17
median		27	18	17
sd		3	3	2
max. possible score		32	26	20
max. score		32	25	20
min. score		16	9	12

**Table 6.7. NUMBER (PERCENTAGE) OF COMPETENT STUDENT TEACHERS AT 80% PERFORMANCE LEVELS ACROSS PROGRAMMES BY BEHAVIOURAL SKILLS**

Prog	No. of Subjects tested	Definitional and General Knowledge (DGK)	Process Skill (PS)	Problem solving and Application skill (PsAS)
A	15	11 (73%)	8 (53%)	13 (87%)
B	20	15 (75%)	14 (70%)	17 (85%)
C	15	11 (73%)	10 (67%)	13 (87%)
D	10	6 (60%)	8 (80%)	9 (90%)
E	30	22 (73%)	15 (50%)	26 (87%)
F	70	36 (51%)	26 (37%)	48 (69%)
G	20	13 (65%)	10 (50%)	16 (80%)
H	30	22 (73%)	13 (43%)	25 (83%)
I	5	3 (60%)	2 (40%)	5 (80%)
J	5	2 (40%)	3 (60%)	4 (80%)
K	20	11 (55%)	5 (25%)	15 (75%)
L	25	15 (60%)	12 (48%)	22 (88%)
<b>ALL</b>	<b>265</b>	<b>167 (63%)</b>	<b>126 (48%)</b>	<b>212 (80%)</b>
mean score		19	45	8
mode		20	44	8
median		19	45	8
sd		3	4	1
max. possible score		24	57	10
max. score		24	54	10
min. score		10	27	5

The first of the two questions listed at the beginning of this chapter was about the level of understanding of the subject matter of the NNMC by overall population of student teachers passing out of colleges of education in Nigeria. That is

**Question 4:** What level of understanding of school mathematics subject matter in Nigeria do student teachers possess at the terminal point of training as their basis for teaching the NNMC?

In other words, how well can a teacher, after exposure to a mathematics teachers' training programme in Nigeria, recall specific facts in school mathematics, display



knowledge of terminology, recognise concepts, principles and rules in school mathematics, carry out algorithms, and transform problem elements from one mode to another and solve them with relative mathematical knowledge? These are some of the specific objectives of mathematics instruction at the secondary school level. In order to realise these objectives mathematics teachers must first be able to demonstrate them by themselves. Teachers are supposed to know a lot more than their students to be able to guide pupils through a lesson.

Table 6.5 indicates that only 187 (71%) of the 265 student teachers tested achieved overall competence at the prescribed performance level of 80%. Put differently, approximately 30% of prospective student teachers, at the point of graduating, understood less than 80% of the mathematics content of the syllabus which they were about to teach. This result may not, in any case, be entirely due to student teachers' lack of understanding of content. Other factors such as, for instance, the nature of the test (bearing in mind the degree of reliability obtained) could have contributed.

The proportion of student teachers found not to be competent is, however, sufficient to raise some concern, in view of the fact that the 80% performance criterion used to determine student teachers' level of understanding, included all student teachers who obtained the average "true" score of 66.5 (or 76%) and above.

Also, from Table 6.6, it is noticed that the proportion of student teachers who achieved competence in geometry and trigonometry was very small. Only 43 (16%) of the 265 student teachers tested knew 80% of the subject matter in this content area. Achievement in the other two content areas were not altogether encouraging either. The highest number of competent student teachers was 215 or 81% in Algebra. In number and numeration (arithmetic) only 74% demonstrated competence.

In particular, nine questions (questions: 26, 45, 48, 72, 79, 81, 93, 99 and 100) caused student teachers problems. Two of these (questions 26 and 72) dealt with number and numeration. Question 26 tested student teachers' ability to apply the four basic mathematics operations on numbers in a base other than the conventional base 10. Question 72 dealt with sorting and classification using a Venn diagram. Both of these are still considered to be "modern mathematics" topics in Nigeria. They also appear in the Nigerian schools mathematics syllabus.

Six of the problem questions (nos. 45, 48, 79, 81, 99 and 100) tested various levels of spatial knowledge: identification, definition and recall of facts. Four of them (45, 48, 81 and 99) involved Euclidean geometry while two (79 and 100) require knowledge of school trigonometry. Question 81 tested the ability of student teachers to either apply or follow deductive reasoning in proving riders in Euclidean geometry. The various concepts and topics tested in these six questions also appear in the Nigerian schools mathematics syllabus.

Finally, from Table 6.7 we notice also that the number of student teachers who demonstrated the named behavioural skills with competence was small. This was especially so in their demonstration of process skills. Only 48 percent of student teachers demonstrated process competence. That is, less than half of the student teachers tested were able to read and interpret a routine problem, display knowledge of terminology, recall specific facts, identify relevant and appropriate processes, select correct operations and then carry out algorithms needed to solve the routine problem.

The answer to question 4 is thus:

**Answer 4:** At graduation, prospective student teachers in Nigeria do not understand school mathematics contents well enough to be able to teach in schools with confidence.  
(Only approximately 70% of student teachers, at the terminal point of their training, understood 80% of school mathematics subject

matter which they were about to teach in Nigeria. In particular, student teachers found topics in geometry and trigonometry difficult; less than half (43%) understood 80% of the subject matter in this content area. The lowest level of ability was in the performance of process skill; approximately 48% (less than half) of student teachers demonstrated competence in process skill in school mathematics.)

#### **6.4.3. Differences in overall competence between programmes**

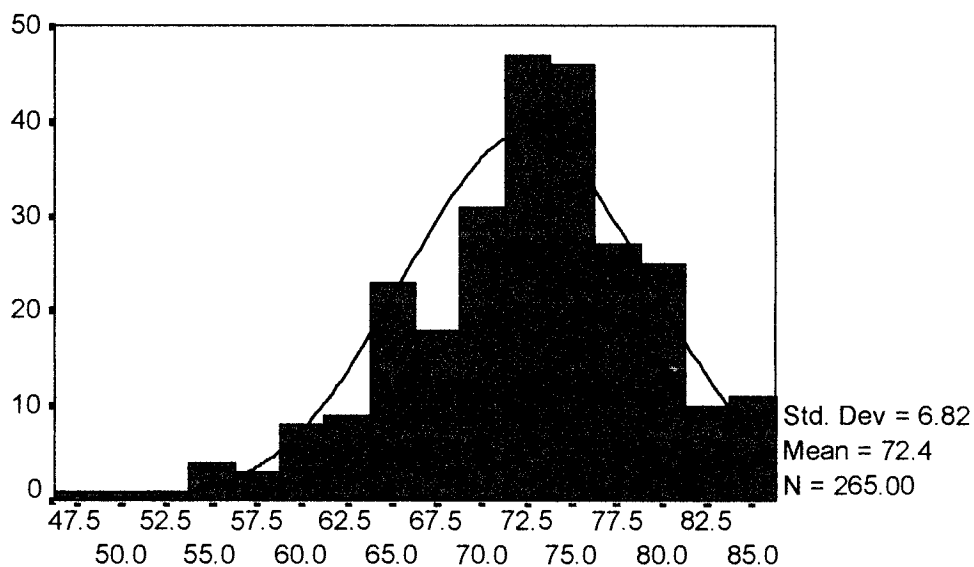
The second question we set out to answer in this chapter, was about variations between programmes in the level of understanding of school mathematics subject matter by student teachers. That is

**Question 5.** Are there any differences at graduation in the level of subject matter understanding of student teachers passing out from different colleges of education in Nigeria?

In other words, did demonstrated levels of understanding of school mathematics subject matter, by student teachers, vary from college to college according to training programmes employed in their training? Were some training programmes producing subject matter competent teachers while others were failing?

In addition to Table 6.5 and Figure 6.1, Table 6.8 shows some relevant statistics associated with student teachers' scores on the overall test. Figure 6.2 displays the distribution of aggregate scores.

Figure 6.2 DISTRIBUTION OF AGGREGATE SCORES ON THE SMCT



aggregate score

Table 6.8. RELEVANT STATISTICS ASSOCIATED WITH SCORES ON THE SMCT

Group	Count	Mean	Standard Deviation	Standard Error of Mean	MINI	MAX.
A	15	76.1	6.9	1.8	64	86
B	20	74.9	4.5	1.0	66	86
C	15	74.2	8.3	2.2	55	84
D	10	75.2	6.0	1.9	66	85
E	30	74.4	6.0	1.1	61	86
F	70	70.3	7.2	0.8	47	86
G	20	73.3	5.1	1.0	66	82
H	30	71.8	8.0	1.4	49	84
I	5	72.2	3.3	1.5	70	78
J	5	71.8	5.2	2.3	65	77
K	20	68.7	6.3	1.4	53	77
L	25	72.5	6.7	1.3	60	81
<b>Total</b>	<b>265</b>	<b>72.4</b>	<b>6.8</b>	<b>0.42</b>	<b>47</b>	<b>86</b>

From mere inspection of Table 6.5 and Figures 6.1 and 6.2, it appeared that there were differences; that some programmes did better than others in producing competent student teachers from their initial intakes. For instance, at the 80% performance level programmes B and I seemed to be better in turning out more content competent student teachers (95% and 100% respectively) than others and programmes F and K seemed the least efficient. A 5% increase in performance level (see the last column of Table 6.5), however, showed programme D instead of B and I, as the most efficient programmes. And, yet again, programmes F and K (and this time I) as least efficient.

Also, from Table 6.8 the overall range of scores on the SMCT as a whole was 47 to 86. The mean score was 72. Focusing on the ranges, means and standard deviations of scores of students, within programmes, the same pattern of differences was noticed. For instance, the range of scores of student teachers in programme F is from 47 to 86 with mean 70 and standard deviation of approximately 7; while for students in programme I the range is from 70 to 78 with mean 72 and a much smaller standard deviation of less than 4; indicating that a student teacher chosen at random from a mixed population of students from the two programmes, if declared competent, was more likely to have been trained under programme I. There were other similar patterns and differences that could be discerned by merely looking at this table. The overall impression, therefore, was that there were differences, on graduation, between programmes in the level of understanding of school mathematics subject matter of student teachers.

Observations are, however, unreliable since it is difficult to discern associations (and indeed only too easy to misinterpret what one does see) from mere inspection of a multi-way contingency table. Was there, then, sufficient evidence to support the conclusion

that competence was associated with programmes employed for training?. In other words were the perceived differences statistically significant?

It was decided to test statistically whether competence depended on the programme under which a student teacher was trained. Whether, for instance, the twelve programmes could be regarded as representing the population of programmes in colleges of education in the country. Also, whether the observed sample differences signified differences among population or whether they were merely the chance variation that were to be expected among random samples from the same population.

The Chi-square procedure was preferred for this test for two reasons:

- a) The observed frequencies could be represented in the cells of a two-way contingency table as shown in Table 6.9,
- b) Although the two variables - *competent* and *not-competent* - (see once more Table 6.9) were not true dichotomies, but artificial ones created from interval data (scores on the SMCT), they were, for our purpose, both nominal and true quantitative variables.

**Table 6.9. TWO-WAY CONTINGENCY TABLE:  
PROGRAMMES BY COMPETENCE AT 80% LEVEL OF SUBJECT MATTER UNDERSTANDING**

PROGRAMMES	LEVELS OF UNDERSTANDING		TOTALS
	Competent	Not competent	
A	13	2	15
B	19	1	20
C	13	2	15
D	8	2	10
E	23	7	30
F	37	33	70
G	15	5	20
H	23	7	30
I	5	0	5
J	3	2	5
K	11	9	20
L	17	8	25
TOTALS	187	78	265

The calculated  $\chi^2$  ( $\approx 25.8$ ) is greater than  $\chi^2_{11(5\%)} (=19.7)$  or  $\chi^2_{11(1\%)} (=24.7)$ . The chi-squared test, thus, indicated that, at both the 5% and 1% levels, there was significant association between the variables: competence (or level of subject matter understanding) and training programmes. In other words, the probability that data as extreme as the observed would arise less than 1% of the time if there were no differences between programmes is significant. We therefore conclude that there are differences between programmes. The implied  $H_0$  (that there are no association) was, thus, rejected.

The rejection of  $H_0$  by means of chi-square, however, only establishes the existence of a statistical association between level of understanding of school mathematics subject matter and training programmes used; it does not necessarily measure the strength of the association.

Several measures of strength of association for nominal data have been proposed (see for instance, Reynolds, 1984). One such measure, for a two-way contingency table involving variables with more than two categories, that mimic the correlation coefficient by having a maximum absolute value of 1 for perfect association and a value of 0 for no association, is the Cramer's V statistic. The Cramer's V statistic ( $= 0.00542$ ) obtained for the data of Table 6.9 showed that the association between student teachers' level of understanding of school mathematics subject matter and training programmes was strong. The answer to question 5 is thus:

**Answer 5:** There were significant differences between programmes, in the level of school mathematics subject matter understanding amongst student teachers at graduation when comparing the twelve programmes. In other words, student teachers' level of competence in school mathematics subject matter depended on the training programme under which a student teacher was trained.

#### **6.4.4. Differences between programmes in student teachers' performances in the content areas and behavioural skills**

Because we have established the existence of a strong association between overall competence and programmes it was decided to further investigate two questions implicit in the design of the SMCT. These were questions about differences in the performances of student teachers in the four content areas of the NNMC and in the three behaviour skills adopted for this study. The two questions that were raised and investigated, as a result of this, were as follows:

**Question 5-1:** Are there significant differences between programmes in student teachers level of understanding of subject matter, at graduation, in each of the content areas of the NNMC?

**Question 5-2.** Are there significant differences between programmes in student teachers demonstration of knowledge/skill, at graduation, in the three behavioural levels specified in this study?

Table 6.10 shows the number (and percentage) of competent students teachers, at 80% performance level in three of the four content areas of the NNMC.

The number of items in the SMCT in Basic Statistics component is very small to justify either a meaningful estimate of the reliability coefficient of the sub-test or a statistical comparison of mean scores in that content area. However, items difficulty estimates (see section 6.4.1) indicate that the overall percentage of student teachers who responded correctly to the four items in this content area (that is items 64, 65, 66 and 67) ranged from 82% for question 67 to 89% for question 64. Also, looking at the distribution of student teachers who answered the four questions correctly, suggests a tendency towards the conclusion that there were no differences between programmes in student teachers' performances in this content area.

Table 6.11 shows the number (and percentage) of competent students teachers at 80% performance level in the three behavioural levels.



**Table 6.10. NUMBER OF COMPETENT (c) AND NOT-COMPETENT (nc) STUDENT TEACHERS IN THREE CONTENT AREAS OF THE NNMC AT 80% PERFORMANCE LEVEL**

PROG ↓	CONTENT AREAS						COUNT
	Number & Num.		Geom. & Trig		Algebra		
	c	nc	c	nc	c	nc	
A	11	4	5	10	14	1	15
B	15	5	3	17	19	1	20
C	12	3	8	7	14	1	15
D	8	2	4	6	8	2	10
E	25	5	6	24	25	5	30
F	50	20	8	62	54	16	70
G	19	1	3	17	17	3	20
H	19	11	3	27	24	6	30
I	4	1	0	5	4	1	5
J	3	2	0	5	5	0	5
K	10	10	0	20	13	7	20
L	20	5	3	22	18	7	25
<b>TOTAL</b>	<b>196</b>	<b>69</b>	<b>43</b>	<b>222</b>	<b>215</b>	<b>50</b>	<b>265</b>

**Table 6.11. NUMBER OF COMPETENT (c) AND NOT-COMPETENT (nc) STUDENT TEACHERS IN THREE BEHAVIOURAL LEVELS AT 80% PERFORMANCE LEVEL**

PROG ↓	BEHAVIOURAL LEVELS						COUNT
	DGK		PS		PsAS		
	c	nc	c	nc	c	nc	
A	11	4	8	7	13	2	15
B	15	5	14	6	17	3	20
C	11	4	10	5	13	2	15
D	6	4	8	2	9	1	10
E	22	8	15	15	26	4	30
F	36	34	26	44	48	22	70
G	13	7	10	10	16	4	20
H	22	8	13	17	25	5	30
I	3	2	2	3	5	0	5
J	2	3	3	2	4	1	5
K	11	9	5	15	15	5	20
L	15	10	12	13	22	3	25
<b>TOTAL</b>	<b>167</b>	<b>98</b>	<b>126</b>	<b>139</b>	<b>212</b>	<b>53</b>	<b>265</b>

The Chi-square procedure was used to investigate the relationship between programmes and each of the variables: number and numeration, geometry and trigonometry and algebraic; and between programmes and the variables: definitional and general knowledge, process knowledge and problem solving and application. Table 6.12 shows the results of the chi-square test.

**Table 6.12. CALCULATED CHI-SQUARE VALUES FOR ASSOCIATION BETWEEN PROGRAMMES AND EACH OF THE SIX VARIABLES OF THIS STUDY**

	CONTENT AREAS			BEHAVIOURAL LEVELS		
	NN	GEOT	ALG	DGK	PS	PsAS
Calculated $\chi^2$	17.2	36.9	12.6	11.0	18.4	11.0
Decision	n/s Accept $H_0$	significant Reject $H_0$	n/s Accept $H_0$	n/s Accept $H_0$	n/s Accept $H_0$	n/s Accept $H_0$

$$\chi^2_{11(5\%)} (=19.7)$$

$$\chi^2_{11(1\%)} (=24.7)$$

n/s = not significant

The results of the chi-square test (see Table 6.12 above) showed that the observed differences in student teachers' performances between programmes was only significant in geometry and trigonometry content area. The differences between programmes in student teachers' performances in all the behavioural levels were not significant. In other words, there was association between competence and programmes adopted for training only in geometry and trigonometry content area. The Cramer's statistic (=0.00042) shows that this association was also strong. Thus, the answer to the two ancillary questions 5-1 and 5-2 are as follows:

**Answer 5-1:** There are significant differences between programmes in the level of understanding of the contents of school geometry and trigonometry by student teachers in Nigeria. But there are no differences between programmes in their understanding of the contents of number and numeration and algebra

**Answer 5-2:** There are no significant differences between programmes in student teachers' demonstration of knowledge/skills in the three behavioural levels investigated in this study.

This is an interesting result because it appears to confirm an earlier result of the difficulty analysis of section 6.4.1 which suggest that student teachers found items in the same content area difficult and that there were significant differences between programmes in the performances of students in this area. Again, it is pertinent to point

out that this result is only indicative, because of the degree of the estimated reliability of the various sub-tests. (see table 6.4 of section 6.2.3)

#### 6.4.5. Comparison of differences between programmes

The Chi-square and Cramer's measures only established that there were overall differences between programmes and that there was strong association between overall competence and training programmes and between competence in geometry and trigonometry and training programmes. Further analysis was, therefore, needed to pinpoint where, the differences or associations there might be between programmes, were located. Tables 6.13 and 6.14 show, respectively, the means of scores of student teachers in each programme group according to content areas and behavioural levels.

Table 6.13. MEAN PERFORMANCE IN THREE CONTENT AREAS ACROSS PROGRAMMES

Content Area	PROGRAMME												
	A	B	C	D	E	F	G	H	I	J	K	L	ALL
NN (n=33)	27.5	27.6	26.9	27.7	28.0	26.5	28.1	26.7	26.8	26.8	26.1	27.5	27.2
GEOT (n=25)	19.6	19.0	19.1	19.7	18.7	16.7	17.4	17.7	16.8	17.0	16.1	17.3	17.7
ALG (n=20)	17.9	17.5	17.6	16.9	17.1	16.7	17.0	16.8	17.0	17.4	16.0	16.8	16.9

Key: NN = Number and Numeration  
 ALG = Algebra  
 GEOT = Geometry and Trigonometry  
 n = The number of items in a content category

Table 6.14. MEAN PERFORMANCE IN THREE BEHAVIOURAL LEVELS ACROSS PROGRAMMES

Behaviour Levels	PROGRAMME GROUPS												
	A	B	C	D	E	F	G	H	I	J	K	L	ALL
DGK (n=33)	20.1	19.7	19.7	18.9	19.6	18.1	19.4	18.9	19.2	18.8	18.2	18.7	18.9
PS (n=58)	46.9	46.8	46.0	48.0	46.2	44.4	45.6	44.4	44.8	44.8	42.6	45.2	45.2
PsAS (n=10)	9.1	8.4	8.5	8.3	8.6	7.8	8.3	8.5	8.2	8.2	7.9	8.3	8.3

Key: DGK = Definitional and General Knowledge.  
 PS = Process Skill  
 PsAS = Problem Solving and Application Skills.  
 n = The number of items in a behavioural category

Tukey's Honestly Significant Difference (HSD) for multiple comparison of significance test (see Kirk, 1982 chapter 3 or Snedecor, 1966 p.251) was used for this purpose; to compare differences in performance between programmes found to be significant (i.e. differences in overall performances and in performances in geometry and trigonometry)

The rationale of Tukey's HSD is that if the means are arranged in order of magnitude and the smallest is subtracted from the largest the probability of obtaining a large difference increases with the size of the array of means. The studentized range statistic ( $q$ ) given by:

$$q = \frac{\sqrt{MS_{error}}}{n}$$

where  $n$  is the number of subjects in each treatment condition and  $MS_{error}$  is the ANOVA error mean square, expresses the difference between a pair of means in any array as so many standard errors of the mean. Tukey's HSD test requires that, to achieve significance,

any pairwise difference must exceed a critical value which depends partly upon a critical value of  $q$ , the latter being fixed by the values of two parameters namely:

(a) the number of means in the array and

(b) the degrees of freedom of  $MS_{(error)}$ .

The test is then made by computing a difference,  $D$ , given by

$$D = q_{\alpha} \sqrt{\frac{MS_{(within)}}{n}}$$

where  $q$ , defined above (with  $\nu$  the degrees of freedom), is the upper  $\alpha$ -percentage point of the Studentized Range distribution.  $D$ , which is significant at the  $\alpha$ -level, is then compared with the  $a(a-1)/2$ <sup>4</sup> sample differences in the experiment. A comparison involving two means is then declared to be significant if it exceeds  $D$ .

Tables 6.14 and 6.15 show the results of Tukey's HSD test with significant level 0.05.

**Table 6.15. TUKEY-HSD TEST WITH SIGNIFICANCE LEVEL 0.05  
(MEANS OF OVERALL SCORES ACCORDING TO PROGRAMMES)**

Prog	mean ( $\bar{m}$ )	K	F	H	J	I	L	G	C	E	B	D	A
K	69	69	70	72	72	72	73	73	74	74	75	75	76
F	70		70	72	72	72	73	73	74	74	75	75	76
H	72			72	72	72	73	73	74	74	75	75	76
J	72				72	72	73	73	74	74	75	75	76
I	72					72	73	73	74	74	75	75	76
L	73						73	73	74	74	75	75	76
G	73							73	74	74	75	75	76
C	74								74	74	75	75	76
E	74									74	75	75	76
B	75										75	75	76
D	75											75	76
A	76	*	*										76

<sup>4</sup> In a group of  $a$  means there are in all  $a(a-1)/2$  potential differences.

**Table 6.16. TUKEY'S-HSD TEST WITH SIGNIFICANCE LEVEL 0.050  
(MEANS OF SCORES IN GEOMETRY AND TRIG. ACCORDING TO PROGRAMME)**

Prog	mean ( <i>m</i> )	K 16	F 17	I 17	J 17	L 17	G 17	H 18	E 19	B 19	C 19	A 20	D 20
K	16												
F	17												
I	17												
J	17												
L	17												
G	17												
H	18												
E	19	*	*										
B	19	*	*										
C	19												
A	20	*	*										
D	20	*	*										

In both Tables 6.15 and 6.16 the group means were arrayed from low to high. The asterisks in the lower part of the matrix in Table 6.15 indicate that there was a significant difference between the overall performances of student teachers trained under programme A and those trained under programmes F and K, but that there were no detected significant differences among the scores of student teachers trained under the other ten programmes. Similarly, from Table 6.16, programmes A, B, D and E each differed significantly from programmes F and K, but they did not differ from each other.

This implied that, when overall level of understanding of school mathematics subject matter by student teachers at the point when they are graduating from colleges of education is our focus of interest, three levels of understanding of subject matter of the NNMC could be distinguished. The three levels, in descending order, are demonstrated by:

- (i) student teachers trained under programme A;
- (ii) student teachers trained under programmes B, C, D, E, G, H, I, J and L; and finally,
- (iii) student teachers trained under programmes F and K.

Similarly, if student teachers' performance in geometry and trigonometry is considered, three levels of understanding could also be discerned. The three levels, again in descending order, are:

- (I) student teachers trained under programmes A, B, D and E;
- (ii) students teachers trained under programmes C, G, H, I, J, and L;
- (iii) student teachers trained under programmes F and K.

It is interesting to note that, in both cases, student teachers trained under programmes F and K demonstrated the least level of competencies. Also students trained under the five programmes (F, G, H, I and J), which did not offer courses in school mathematics contents, were among those who achieved below the set performance level for competence in geometry and trigonometry.

Applying the idea of a Carroll graph<sup>5</sup> to these results, training programmes were then classified into four sets as shown in Table 6.17.

**Table 6.17 SUMMARY OF PROGRAMMES CLASSIFICATION ACCORDING TO TWO VARIABLES  
(levels of understanding of overall NNMC contents and GEOT)**

		LEVELS OF UNDERSTANDING OF NNMC CONTENTS		
		Level 1	Level 2	Level 3
LEVELS OF UNDERSTANDING IN GEOMETRY AND TRIGONOMETRY	Level 1	A	B, D, E	
	Level 2		C, G, H, I, J, L	
	Level 3			F and K

The four programme sets are:

**SET 1:** Training programmes that turned out significantly higher number of school mathematics subject matter competent student teachers from their initial intakes and whose student teachers' exhibited significantly higher overall level of understanding of school mathematics subject matter than those student

<sup>5</sup> In a Carroll graph (or map) the outer rectangle represents the universal set (which, in our present case, is the subject matter of the NNMC and test items of the SMCT). The inner rectangles are the intersections of various subsets of this universal set. Two examples of such subsets are the set of subject matter dealing with geometry and trigonometry and the set of items testing problem solving and application skills, etc.

teachers trained under other programmes. There is only one member of this set. That is programme A.

**SET 2:** Programmes in this set turned out a percentage of school mathematics subject matter competent student teachers from their intakes which is low when compared with programme A. Student teachers trained under programmes in this set, also, exhibited a lower level of understanding of school mathematics than students in programme A, but demonstrated the same level of understanding of school geometry and trigonometry as students in programme A. Programmes in this set are B, D and E.

**SET 3** Student teachers trained under programmes in this set exhibited the same level of understanding of the subject matter of the NNMC as those in set 2 except that they demonstrated a lower level of understanding of school geometry and trigonometry than students trained under programmes in either of the two previous sets. Programmes in set 3 are programmes C, G, H, I, J and L.

**SET 4:** Programmes in this set turned out the least percentage of school mathematics subject matter competent student teachers from their intakes and students teachers trained under them exhibited the lowest level of understanding of school geometry and trigonometry. Programmes in this set are F and K.

Relevant statistics, across these programme sets, is shown in Table 5.18.



**Table 6.18.** ANALYSIS OF DATA ACROSS PROGRAMME SETS

Prog Set	No (%)	mean score	std. dev.	min score	max. score	Number (%) of competent students
Set 1	15 (6%)	76.13	6.94	64	86	13 (87%)
Set 2	60 (23%)	73.09	6.30	55	86	50 (83%)
Set 3	100 (38%)	74.60	6.34	49	86	76 (76%)
Set 4	90 (34%)	69.96	7.00	47	86	48 (53%)
All	265 (100%)	72.40	6.83	47	86	187 (71%)

Question 5.3 below was posed and investigated, as a result of the outcome of the data analysis in the preceding sections of this chapter, in order to find out if the four sets of programmes described by the data of Table 6.18 are indeed distinct sets when student teachers' level of understanding of school mathematics subject matter is the focus of interest..

**Question 5.3:** Are there any significant differences between programme sets in the level of subject matter understanding among student teachers in the four sets (programme sets 1, 2, 3 and 4) described above? In other words, are the identified programmes sets necessarily different?

The  $\chi^2$  test was, again, used to establish the presence (or absence) of an association between competence ( or level of understanding of subject matter) and programme set. The calculated chi-square  $\chi^2 = 20.87$  and the Cramer's measures ( $=0.2806$ ), indicate that there are differences and that some associations between competence and programme sets exist and that some of these are both significant and strong.

Table 6.19. TUKEY'S HSD TEST WITH SIGNIFICANCE LEVEL 0.05  
ON PROGRAMME SETS

Prog Set	means ( <i>m</i> )	Set 4	Set 2	Set 3	Set 1
		69.9556	73.0880	74.6000	76.1333
4	69.9556				
2	73.0880	*			
3	74.6000	*			
1	76.1333	*			

Tukey's HSD test (see Table 6.19), however, indicate that programme sets 1, 2 and 3 (i.e. programmes A; B, D, E; and C, G, H, I, J, L) all differ significantly from programme set 4 (programmes F and K) but do not differ significantly from each other; so that the answer to question 5-3 is as follows:

**Answer 5.3** There is a significant difference between programme sets in the level of subject matter understanding by student teachers. Level of understanding of student teachers in sets 1, 2 and 3 (as one group) differ significantly from those of student teachers in set 4 (as a separate and second group). This difference was in favour of student teachers in programme sets 1, 2 and 3.

Analysis of SMCT scores, thus, revealed two distinct groups of mathematics teachers training programmes in Nigeria. The two groups are shown Table 6.20.

Table 6.20. TWO DISTINCT PROGRAMME GROUPS IDENTIFIED BY THIS STUDY

GROUPS	PROGRAMMES
Group 1	A, B, C, D, E, G, H, I, J and L
Group 2	F and K

### 6.5. Summary

Part of the aim of this study was to determine whether student teachers, passing out of colleges of education in Nigeria, understood the subject matter of the Nigerian National Mathematics Curriculum (NNMC) well enough to teach it in schools in that country; whether there were differences in the level of understanding of this subject matter and whether these differences (if they existed) depended on the training programme under which a student teacher was trained.

A school mathematics contents test (SMCT), based entirely on the NNMC, was constructed and administered to 265 student teachers chosen at random from 53 colleges of education in Nigeria. The analysis of the data, generated by the SMCT, showed that:

1. At the end of their third year of training at colleges of education in Nigeria only about 70 percent of student teachers understood at least 80 percent of the subject matter of the Nigerian National Mathematics Curriculum (NNMC) as their basis for teaching it. In general, student teachers across colleges of education experienced difficulties with items dealing with geometry and trigonometry.
2. There were significant differences between programmes in the level of understanding of school mathematics subject matter by student teachers. Competence in the subject matter of the NNMC was strongly associated with the type of training programme adopted. Student teachers trained under programme A exhibited a level of subject matter understanding that was higher than that exhibited by student teachers trained under programmes B, D, and E, who in turn were better than student teachers trained using programmes C, G, H, I, J and L. Student teachers trained under programmes F and K exhibited the lowest level of understanding of school mathematics subject matter. This finding suggests that some mathematics teacher training programmes were more

successful at producing content competent student teachers from their intakes than others. Programme A appeared to be the best in the performing this function. This may, however, be due to some other factors such as better teachers, better facilities, higher entry requirements or, indeed, better intakes, and so on.

3. There were also differences between programmes, in student teachers' performances, in each of the four content areas of the NNMC. The differences were, however, found to be significant for student teachers' performances in the geometry and trigonometry content area only. Programmes A, B, D and E were likely to produce more student teachers with a higher level of understanding of school geometry and trigonometry than did programmes C, G, H, I, J and I. Programmes F and K were the least efficient in this respect also.

4. There were no significant differences, between programmes, in the level of behavioural knowledge/skills demonstrated by student teachers. In general, student teachers exhibited a lack of adequate process skill in mathematics. It is, however, arguable whether this finding can be sustained, in view of the estimated degree of reliability of the sub-test for this constituent component.

5. A marked significant difference existed, between programmes, in the level of understanding of overall school mathematics subject matter by student teachers trained under ten of the twelve programmes (taken together as one group) and those trained under the remaining two programmes; F and K, (taken together as a separate and second group). The analysis, thus, identified two distinct groups of mathematics teachers training programmes in Nigeria, according to the levels of understanding, by student teachers trained under them, of the subject matter of the Nigerian National Mathematics Curriculum (NNMC) in general, and geometry and trigonometry in particular.

6. Finally, coupled with the fact that our criterion for an affirmative answer to the question of relevance of training curricula to the school mathematics curriculum or a content area of the school curriculum was not achieved by the overall sample of student teachers or any group of students in any programme group (see section 6.3 of this chapter), these results suggest, as was the case with the analysis in chapter 5 (see section 5.8, page 140), the following answer to questions 3 of this research:

**Answer 3.** In general, the mathematics content of the curricula for training school mathematics teachers at colleges of education in Nigeria, may not be related to the subject matter of school mathematics in that country. The programmes differed in the amount school-level mathematics they offered and, probably as a result, only 71 percent of student teachers exposed to these curricula, were found to possess minimal content knowledge expected of a school mathematics teachers at the terminal point of their training.

**CHAPTER 7**

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**ANALYSIS OF DATA FROM TEACHER TRAINERS ASSESSMENT OF PROGRAMMES (TAMP) QUESTIONNAIRE**

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**7.1 Introduction**

The Teacher-trainers Assessment of Mathematics Programme (TAMP) questionnaire was designed and administered to teachers trainers (in most cases, heads of mathematics departments in colleges of education in Nigeria) in order to solicit their views on the state of mathematics teacher education in the country. A copy of the questionnaire is attached as Appendix E. (page 336)

The questionnaire sought to collect information from teacher trainers about their;

- background;
- perception of the objectives of mathematics teacher education;
- views on what they consider the most relevant issues for the curriculum for training teachers of mathematics in Nigeria;
- views about the mathematics teacher training programmes in their institutions.

A total of 53 questionnaires were sent out or handed to teacher trainers selected at random from colleges of education in the country. But because of the reasons and difficulties already explained in section 4.1 of this study the response rate was very poor. Only 17 teacher trainers responded to the request to complete and return the questionnaires.

The analysis of the information gathered from this was, however, carried out in the hope that the results would be useful in explaining the results of the analyses in the two preceding chapters.

This chapter, therefore, analyses responses from college lecturers in Nigeria who were responsible for the training of teachers to teach mathematics in schools.

## 7.2. Background of teacher trainers

The qualifications, educational training and other experiences relevant for the job of training mathematics teachers show that of the 17 respondents 13 were graduates and only 4 had other qualifications (e.g. HND NCE/ADE) with years of experiences ranging from 2 to 21 years. Also, while there was a fair spread of graduates within eight institutions, six showed shortages of graduate lecturers to the extent that mathematics and mathematics education were likely to have been taught by non-graduates in those institutions.

From responses to item 7, which sought information about the qualifications and experiences of other trainers in the mathematics department, more than 80% of the teacher trainers at the colleges of education were found to be professional mathematics educators with less than 20% not professional mathematics educators (i.e. they hold qualifications in mathematics but not trained to teach).

This finding was not surprising since the colleges of education were established purely with the objective of training teachers. Consequently their staff employment policy must have given priority to graduates with educational expertise.

Also, nearly all mathematics teacher trainers were department based: that is they were all members of the mathematics department in the institutions where they taught.

Table 7.1 displays the responses of the teacher trainers to items 8 and 9 which asked whether trainers had taught mathematics at the secondary school level prior to joining the colleges of education and whether they felt the job of training mathematics teachers was the most suitable and enjoyable work in view of their qualifications.

**Table 7.1. TEACHER TRAINERS EXPERIENCES WITH MATHEMATICS TEACHING AND SUITABILITY TO THE JOB OF TRAINING SCHOOL MATHEMATICS TEACHERS**

RESPONSES	TAUGHT MATHEMATICS IN SECONDARY SCHOOL?	SUITABILITY TO MATHEMATICS TEACHER EDUCATION?
YES	5 (29%)	11 (65%)
NO	12 (71%)	6 (35%)
TOTAL	17 (100%)	17 (100%)

The table shows that over 70% of respondents had no job experience involving teaching in the secondary/primary school levels. However, only about 35% felt that in view of their qualifications and experiences, their involvement in the school mathematics teacher training exercise was not the most suitable job for them. Hence, for whatever reason such teacher trainers were participating in the training programme, they strongly felt that they were in the wrong place.

Most of the trainers who felt this way were graduates who neither held an education qualification nor had any pre-college of education teaching experience that could have familiarised them with the objectives, philosophy and perhaps the teaching strategies for mathematics. If this is true, it could be an indication that the mathematics teacher training programmes in Nigeria were taught by a substantial number of staff who were both inexperienced and unenthusiastic about the job they were doing.

### **7.3. Perception of the objectives of mathematics teacher education by teacher trainers**

Teacher trainers' descriptions of their understanding of the objectives of mathematics teacher education (item 10) reveal less wide range of descriptions than were present in the preambles of the sample programmes analysed in chapter 5 or in the National Policy on education. While the descriptions given in the programmes and the national policy could be grouped into seven categories; those of the teacher trainers fitted into only three of the seven categories (see figure 7.1).



TABLE REDACTED DUE TO THIRD PARTY RIGHTS OR OTHER LEGAL ISSUES



**Source:** National Commission for Colleges of Education "Guidelines to Colleges of Education" Vol. 2, No. 1, 1995

Eleven of the trainers ( approximately 60%) described their understanding of the objectives in the context of category two; many of these also believed that the main purpose of training mathematics teachers was to help them demonstrate convincing enthusiasm and intellectual ability for further studies in mathematics. However, six, all of whom were professional mathematics teacher educators, were able to offer broader definitions of the aims/objectives of school mathematics teacher education that spanned three categories and included category seven. This narrow understanding, by a majority of the trainers, suggests that teacher trainers in Nigeria had not yet acquired a holistic view of the range of interests which mathematics stands for as embodied in the Nigeria national mathematics curriculum and as reviewed in the first chapter of this study.

#### 7.4 Perception of mathematics programmes in own institution

Items 11 to 14 of the TAMP requested teacher trainers to give their assessment of some aspects of the mathematics teacher training programme in their own institutions. In particular, item 13 asked them to list any three significant features of their training for school mathematics teachers which they considered most important in enhancing the trainees effectiveness for the job. In other words, the trainers were expected to list some competencies that they hoped would be acquired by a student who goes through their training course in order to build competence in handling the job of teaching mathematics in schools. Surprisingly 10 (59%) of the 17 trainers did not attempt to respond to this question; most of these were non-professional mathematics educators. All the same, a couple of trainers with this background who had gone through some in-service (INSET) courses for school mathematics teacher trainers gave impressive responses.

There was a significant number of mathematics education graduates among those that offered no response to item 13. These, however, indicated that they had not acquired enough experience to respond to the question adequately.

The responses of the remaining 7 trainers offered the following range of competencies which they believe their students teachers would acquire in the course of their training to teach mathematics effectively:

- understanding of the meaning and philosophical basis for mathematics, the NNMC curriculum and its translation into lesson units and awareness of methods/resources needed for teaching it;
- mastery of reasonable subject contents (knowledge) from various areas of advance level and first year university mathematics in readiness for gifted school pupils who may need help;
- mastery of reasonable subject content to be able to teach mathematics up to the senior secondary level;

- the concept of an integrated mathematics content, de-emphasising content area boundaries and ability to present a holistic view of mathematics;
- acquire competence in teaching mathematics by enquiry (investigation) and activity-based approaches;
- develop a scientific attitude and competence in mathematics process skills and algorithmic skills;
- acquire competence in improvisation using locally available materials;
- rich educational background on how children learn mathematics;
- acquire skills of classroom presentation through practical teaching; and
- capability of curriculum development planning and implementation.

In item 11, which specifically asked trainers to assess their own programmes in terms of its appropriateness for the task of preparing student teachers to teach the core contents of secondary school mathematics, as many as nine said they believed their programmes to be inappropriate but felt unable to influence any changes. All nine, in response to question 12, chose primary and junior secondary schools as the levels of the school system for which the programmes were inappropriate.

Five trainers were certain that their programmes were appropriate and three felt unable to answer the question; one claimed, in addition, that he had no expertise that enabled him to assess that aspect of the programme.

In an attempt to find out what problems mathematics teacher education in Nigeria might be facing, teacher trainers were requested in item 14 to assess the programme in their colleges and list from their personal experiences three things considered as bottle-necks to the smooth running of the mathematics teacher training. In other words, their observations of what were to count as weak points of the school mathematics teacher training programmes in their various institutions. They were also required, in item 15 to conclude this section by further describing ways they thought their training programme could be improved.

Problems or weaknesses listed related to the curriculum, personnel, facilities/materials and enrolment (admission). A summary of the responses are as follows:

- Lack of purpose-built mathematics laboratories. (Even when available they were often ill-equipped. Most laboratories do not have services of technicians/ technologists particularly needed to assist the trainers in organising practical demonstrations and/or in building concrete models to be used in training for practical teaching).
- Lack of textbooks and library facilities.
- A majority of the trainers lack the necessary training and experiences to participate effectively in the programme and there is little provision or incentive for in-service training.

Massive curriculum content that encourages rushed work instead of careful and meaningful teaching. This view was particularly expressed by trainers in institutions where mathematics still flourishes as a single major (i.e. combining it with another discipline). Three of the 17 respondents claim their colleges run the "single major" programme in mathematics. These are distributed amongst programme groups F, J and K. The time constraint for curriculum coverage has been more severe between 1992 and 1994; due largely to the unstable academic calendar caused by the incessant unrest that has characterised Nigeria throughout this period.

- The admission standard is quite low as even candidates with eminently weak results in the pre-requisite subjects (mathematics and English language) or even worst still some with none of the required basic mathematics background were admitted into the programme. This, it was claimed, made the teaching of basic mathematics contents tedious and most often, such weak students tend to find the course difficult to cope with. On the other hand, there is the difficulty in finding qualified candidates to enrol for the course; the reason being that such candidates resist putting in for the course fearing that a career in mathematics teaching has a 'dead-end' - that is its graduates will be restricted to teaching in secondary schools all their lives. Secondly they are at the same time apprehensive of what the future holds for those who have ambitions for further academic career in mathematics, bearing in mind the already existing apathy shown by a

number of Nigerian universities towards admitting candidates with NCE qualifications into other faculties apart from education.

The following are a selection of suggestions offered by the teacher trainers as ways the training programmes could be improved:

- employing and mounting intensive workshops for the teacher trainers particularly for those without teaching qualifications to familiarise them with the meaning, philosophy and teaching strategies for mathematics;
- provision of purpose-built laboratories, where necessary, as well as equipping them reasonably;
- review of the curriculum to fit the time scale of training as well as reviewing the admission standard/policy to match the demand of the course and maintain a reasonable student-teacher ratio for effective teaching and classroom management;
- provision of relevant textbooks and library facilities;
- make all pre-service teacher training for mathematics full-time; in order to lay a good foundation which is less likely with the part-time programme often suffering regular interruptions from irregularities in the yearly academic sessions. (These incessant disruptions, usually from unrest, have in the past had a lot of negative effect on part-time programmes with the result that the students are rushed through the courses disadvantaged.);
- phase out single major mathematics programmes in favour of the double major programmes.

### 7.5. Summary

Analysis of responses reveal that:

1. In some training institutions in Nigeria, mathematics and mathematics education courses are taught by non-graduate lecturers.
2. Most graduate teacher trainers have no teaching qualifications and no secondary school teaching experience prior to joining the colleges of education and are dissatisfied with their jobs as mathematics teacher trainers.
3. Teacher trainers appear, in general, not to be clear about the aims and objectives of teacher education as embodied in the NNMC or the Nigerian National Policy on Education.
4. Most teacher trainers believe that schools mathematics teachers training programmes in their institutions are inappropriate for the task of preparing prospective teachers for their roles as mathematics teachers; particularly for the primary and junior secondary levels of the Nigeria education system.
5. Some colleges of education offer mathematics in combination with one other specialist subject, e.g. chemistry, physics, geography or biology.
6. Teacher trainers are not happy with the present admission system/policy which allows candidates with little background in mathematics and English language to be admitted for training.
7. Finally, teacher trainers point to weaknesses in their programmes, particularly "massive curricular content" with little time and incentive, and inadequate facilities to allow proper teacher training. They, also, made a number of suggestions and recommendations which they felt would improve mathematics teacher education programmes in Nigeria.

## CHAPTER 8

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### DISCUSSION

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#### 8.1. Introduction

This research sought to describe the characteristics and quality of the training provided for school mathematics teachers in Nigeria. Data was sought to answer the following six questions:

- 1) What conditions or programmes exist for the training of school mathematics teachers in Nigeria?
- 2) In what respect do school mathematics teachers training programmes in Nigeria differ among themselves? In other words, if they differ how are they different?
- 3) In Nigeria, is there any relationship between the mathematics teacher training curricula and the school mathematics curriculum for which teachers are being prepared to implement?
- 4) What level of understanding of school mathematics subject matter in Nigeria do student teachers possess, at the terminal point of training, as their basis for teaching the NNMC?
- 5) Are there any differences between programmes in the level of subject matter understanding of student teachers passing out from different colleges of education in Nigeria?
- 6) In Nigeria, is there any relationship between the curricular provisions for the training of school mathematics teachers and the needs of trainee teachers?

Three different methods of data collection were used.

To address questions 1 and 2, data were collected by means of a content checklist and a teacher trainers' questionnaire. A school mathematics contents test was used to provide data with which to answer questions 4 and 5. The analyses of the data collected using these three methods were presented in chapters 5, 6 and 7. It was hoped that the results of the analyses would provide information with which to answer questions 3 and 6.

There is virtue in employing this type of (multiple methods) approach that generates both quantitative and qualitative data. They can be used to address different but complementary questions within a study. They can, also, be used to enhance the interpretation of, for instance, a primarily quantitative study by a qualitative narrative account. Conversely, a qualitative account may be the major outcome of a study, but it can be enhanced by supportive quantitative evidence used to buttress and perhaps clarify the account.

Also, it is impossible to avoid the confounding effects of methods used on the measurements obtained. With a single method, some unknown part or aspect of the results obtained is attributable to the method used in obtaining the result. Because we can never obtain results for which some method has not been used to collect them, the only feasible strategy, according to Blaikie (1991), is to use a variety of methods.

This was the rationale that informed the use of the three different data collection methods for the present study, which (as with all social research) relied on the "human instrument"; in the sense that, as Miles and Huberman (1984) put it,

...(the researcher) is a one-person research machine: defining the problem, doing the sampling, designing the instrument, collecting the information, reducing the information, analysing it, interpreting it, writing it up..." (p. 230)



The substantial body of research evidence on the fallibility of the human in making the judgements involved in these kinds of activities was reviewed in Nisbett and Ross (1980). Many pitfalls centre on representativeness being assumed when it is suspect; so that, in general, social research has to face the criticism that the work is unreliable and invalid. The present study falls within the same category for criticism. It used samples that the researcher honestly assumed to be truly representative but which, for reasons beyond his control and as already detailed in section 4.1, may not be so. It also used one instrument (the test) whose validity may have been reduced because of the corrections effected to it after it had been administered. Besides, this researcher, being human, is like all humans, fallible.

Several techniques have, however, been suggested to reduce the effects of assumptions on the validity and reliability of data gathering methods and, hence, enhance the credibility of a research. One of the techniques is triangulation, which is the use of evidence from different sources, or methods of collecting data or investigators (where feasible) or even theories. Its main advantage is in the interpretation of results of analysis of data where the trustworthiness of the data is always a worry. It provides a means of comparing a result from one source of information with results from other sources. If two sources give the same message then, to some extent, they cross-validate each other. If there is a discrepancy, its investigation may help in explaining the phenomenon of interest. In other words, it improves the quality and accuracy of findings. This is the technique that is applied in the discussion that follows.

The analyses in chapters 5, 6 and 7 revealed a number of interesting results. These are discussed in the following sections under three main headings: characteristics features of mathematics teacher training programmes in Nigeria, levels of understanding of

school mathematics contents by student teachers and, relationship of curricula provisions to school mathematics and to the needs of student teachers.

## **8.2. Characteristic features of mathematics teacher training programmes in Nigeria**

The 'characteristic features' of a training programme, in the context of this research, was defined in chapter 5 (section 5.2) in terms of three factors: presage, process, and product; and described as concerned with the:

- entry requirements for candidates wishing to be trained as teachers;
- selection procedures for admitting the candidates;
- level of the education system for which the teachers were being trained (i.e. target for graduates after training);
- method and mode adopted for training;
- length of time for which training was to be undertaken;
- total experiences of the student teachers in terms of taught contents (e.g. mathematics, educational studies and pedagogical courses); and the
- actual behaviour expected of a trainee at the end of training and how this was to be measured (e.g. certification standards and evaluation/assessment procedures).

These are now used as a framework for our discussion.

### **8.2.1. Entry requirements**

The analysis of programmes contents in chapter 5 revealed that entry requirements vary from as high as five credits in GCSE/SSC/GCE 'O' levels or five merits in TC2 or equivalent qualifications to two credits or merits at the same or equivalent examinations. Some institutions, however, insist on credits in one of mathematics, basic mathematics, arithmetic processes, or a science subject and English language. This, to me, appears

to be a reasonable requirement since, as was evident from tables 5.7 and 5.8 and the Nigeria school mathematics curriculum description given in section 2.3 of chapter 2, the subject matter to which the trainees are being exposed is largely mathematics. The same analysis showed, however, that programmes F and K admit candidates with lower qualifications.

Also, in analysing the data from the teacher-trainers' questionnaire (chapter 7), it was found that in response to item 14 about what they considered as major weaknesses in mathematics teachers training programmes in their institutions, teacher trainers included the calibre of candidates that come into colleges to train as mathematics teachers. They claimed that, because majority of candidates have weak backgrounds in mathematics, trainees tend to find the course difficult to cope with. They blamed the policy which allowed candidates with little background in mathematics and English to be admitted for training. This, to me, is "passing the buck".

Presumably, most of the candidates admitted to programmes F and K, under their concessionary admissions policy, are mature students who, although they studied school mathematics a long time ago, did not obtain grades good enough to qualify them for entry to a college of education at the time. They invariably would, also, include grade III teachers who had taught in primary schools for a long time and wished to take advantage of training to upgrade to junior secondary school teaching. Such candidates were trained in what was known as teacher training colleges (TTC) before the advent of the Advanced Teachers Colleges (ATC) in 1973. They were, thus, unlikely to have studied school mathematics because, according to Lassa (1978), they only took courses in arithmetic processes.

It is known (e.g. NCCE, 1994) that these potential non-qualified applicants number between three and seven thousand and that they are scattered all over the country. It

stands to reason that they will continue for the foreseeable future to seek admission to colleges of education. Would it, then, not be more profitable to take this available source of potential applicants into consideration in determining entry requirements and to consider their needs when planning the contents for training?

Teacher education is a goal-oriented educational activity, related to the equipping of the individuals with a set of skills which will enable them to function more effectively in a professional environment. Fortunately, this is also a reasonable working definition of the goals of school mathematics; so that, rather than blaming the quality of their intakes, teacher educators can profitably apply the principles of course design from school mathematics, which focuses on and ends with a consideration of the needs of the learner, as a source of ideas in the design of training programmes for teacher education. (Incidentally, this model was applied by the NERC<sup>1</sup> in the design of the national mathematics curriculum).

That teacher trainers feel as they do about the admission policy, which they themselves implement, points to a clear mismatch between published entry requirements and what it should be and between training provisions and the needs of trainees. The low level of understanding of subject matter exhibited by student teachers on the SMCT points to one possible effect of this situation on the products of training programmes that exhibit this mismatch.

### **8.2.2. Selection procedures**

Linked to the problems associated with the admission requirements is the selection process adopted by individual colleges of education. The analysis of programmes content revealed that in selecting candidates for training, almost all programmes depend

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<sup>1</sup> Nigerian Educational Research Council

largely on review of application forms and evidence of qualification(s) submitted by candidates. Seven programmes were found to conduct interviews as an extra step, probably, to ascertain candidates' preparedness, convictions and understanding of the implication for their choice of career. This is important, as it will help teacher educators to select the most suitable candidates; not only in terms of paper qualification but also in terms of interests in, potentials for, and attitude toward teaching as a career.

It is, perhaps, pertinent to point out that in Nigeria candidates, qualified (under existing published entry requirements) for admission to colleges of education to train as mathematics teachers, are usually very few. Training institutions compete with each other for such candidates to the extent that persuasion, in the form of free tuition and promises of college support for applications for maintenance grants from the federal government, is used to entice suitable candidates. It is not surprising, therefore, to find that not all programmes subscribe to using interviews or qualifying examinations as instruments in their selection process. Training institutions, perhaps, see interviews, and qualifying entrance examinations, as unnecessary in the circumstances. This may, also, account for the relaxed admission requirement for entry to programmes, such as F and K, mentioned in the preceding section.

Teacher trainers gave fear of career stagnation in mathematics teaching, made worse by the reluctance of a number of Nigerian universities to admit candidates with the NCE certificate to faculties other than education, as a reason for this shortage.

### **8.2.3. Certification standards**

Another interesting feature revealed by the analyses concerns the certification requirements stipulated in the programmes for the final award of the NCE mathematics certificate. It was found that there are differences between programmes in the minimum

number of credits needed, by a student teacher, to graduate at the end of training and in the manner in which these credits are distributed among the various training components.

Programmes A, B, C, and L will award the NCE certificate to a student teacher who has accumulated a minimum of 82 credits after three years of training, provided that at least 36 of these (or 50% of the credits from taught course-works) are earned from mathematics courses; thus, giving the impression that the designers advocate a balance between subject matter work and education courses. On the other hand, programmes D, E, and K demand a minimum of 100 credits out of which only 28 (or 23 for programme K) credits need to be earned from mathematics courses. While programme J will award the same certificate to a student teacher who accumulate a minimum of 112 credits, but with only 26 from mathematics courses. In each of the last two cases it appears that emphasis was in favour of pedagogical knowledge or education studies.

Also, in collating questionnaire responses from teacher trainers it was found that some programmes ( F, J and K) combine mathematics with other disciplines in what was called the "single major" programmes. Majority of these institutions are also among those that complained about "massive curriculum content" and lack of time.

These differences raise a number of questions. For example: "What criteria were used in allocating credits to courses in a programme?"; "Is a credit in one programme equal to a credit in similar course in another programme?"; If courses are equally weighted, why the differences in minimum requirements for graduation?"; and more important, "Can the NCE certificate awarded by different institutions in the country be considered as equivalent?". What is the difference in status between an NCE in mathematics from a "single major" programme and one from a "double major" programme?

It is not possible from the data collected, using the content checklist and the questionnaire alone, to provide answers to questions which arose as a consequence of the differences revealed in the certification requirements of programmes that were analysed. What is apparent, from the analyses, is that different programmes attach different degrees of importance to different teacher knowledge components. This is bound to create disparity in certification requirements and, consequently, some difficulties in determining accreditation standards. These programmes were designed and first implemented during the mid-1980s, when the controversy over the importance of subject matter versus education course-work, in teacher preparation programmes, was at its height (especially in the US). The controversy was intense and world-wide. The emphasis at the time was on new methods and approaches to mathematics teaching: *how to teach* rather than *what to teach*. Teacher educators in Nigeria who, until recently, had tended to follow and copy curriculum development efforts in developed countries, seemed to have been influenced by the more vocally expounded view at the time.

Also, analysis of student teachers' performances on the school mathematics content test revealed low level of understanding of subject matter mostly among student teachers trained under programmes which gave prominence to education studies (e.g. programmes E, F, G, H, H, J and K; see for instance Figure 6.1 on page 158).

However, literature shows that improvement in teaching performance, although enhanced, will not be achieved by merely raising content knowledge requirements. A balance, such as appears to be evidenced in programmes A, B, C, and L, between a thorough grounding in subject matter and adequate preparation in professional skill and knowledge, is essential in the preparation of novices for teaching. It is interesting that this study, also, showed (see section 6.4.4 of chapter 6) that the differences between

programmes, in the efficiency with which they produced subject matter competent student teachers from their intakes, is significantly better in favour of programmes (e.g. programmes A, B, C and L) which exhibit a balance between subject matter and pedagogy (see figure 6.1. for instance). The analyses, thus, reveal a disparity in accreditation standards for the same qualification in the same country.

#### **8.2.4. Method and mode of training**

All programmes offer full-time training for mathematics teaching. Programmes E, F, H and J offer part-time training also. The full-time training runs for a minimum of three academic sessions. Part-time studies are spread over a period of five years with, at least, one contact session of 8-12 weeks in each academic year, depending on the programme.

Nine of the 12 programmes that were analysed, operate the semester system with actual contact hours of between 180 and 210 per semester. The remaining three programmes operate the term system with actual contact hours of between 120 and 150 hours per term.

Except in the four cases (programmes F, H, J and K) where students are to spend the last of the three years of the training in a school, practical teaching is to be undertaken at varying periods, during the training, for twelve or six weeks. All programmes, however, allocate six credits to the practical training component.

Apart from the disparity in certification standards mentioned earlier, the difficulty in trying to generalise about the standard of the NCE certificate and the quality of student teachers passing out from various colleges of education in Nigeria is, again, highlighted in the differences between programmes in the intensity and the weighting (in terms of credits) given to the same course component. The content analysis revealed, for



instance, that the teaching practice exercises differ, in their intensity (in terms of the actual number of hours a student teacher teaches during this exercise) and in their duration (according to the number of weeks to be spent), by as much as twenty-four weeks between programmes and yet every programme allocate six credits to the teaching practice component.

It would not matter that the arrangements differ, if the sum total of actual teaching time is the same or if the allocation of credits reflects the differences in duration and/or intensity. What determines the number of credits that is assigned to a course or an activity in a college of education in Nigeria or what goes on in teaching practice or the nature of supervision received, is not made clear from the information gathered from the programmes. This, again, points to the anomaly in trying to determine the status of the initial teacher education qualifications for mathematics teachers awarded by colleges of education in Nigeria.

#### **8.2.5. Target destination for student teachers after training**

Another interesting feature of mathematics teachers training programmes in Nigeria that was revealed by the analyses is the contradiction between the stated intentions about the destination of student teachers after training and the provisions actually made in the programmes for their training. The published objectives of the federal government in establishing colleges of education in Nigeria (see, for instance, FME, 1990) include, among others things, "to produce quickly and in large numbers, teachers...who would be needed to strengthen the teaching force at the *primary and junior secondary schools..*". All programmes claim, in their preambles, to be preparing their students for the primary and/or junior secondary schools (see, for instance, Table 5.10 on page 135). But in Table 5.7 (page 130), which shows courses on offer across programmes, the

nature of these courses contradict this undertaking. Most of the mathematics courses on offer in the programmes are not relevant to either the primary or secondary school mathematics syllabuses in Nigeria (compare, for instance, Table 5.7 with Appendix A). Very few programmes offer any mathematics courses that are relevant to either the primary or secondary school mathematics (e.g.; basic concepts in mathematics, school mathematics content, introduction to computers, elementary algebra and trigonometry, or everyday statistics) as compulsory courses.

Given the varied backgrounds of their intakes, (acknowledged, apparently, by teacher trainers) one would expect colleges of education to provide opportunities for a thorough grounding in primary and secondary school mathematics contents. Courses, such as number and numeration, counting and numeration systems in Nigeria, school geometry, problem solving techniques in different cultures in Nigeria etc., would be more relevant and useful to the primary or secondary school teacher in a classroom situation, than Linear Algebra I, II and III or Abstract Algebra or Differential Equations which appear to dominate the mathematics aspect of the training packages on offer. The courses on offer in most programmes do not, therefore, match the needs of the "target destination" professed in the programme preambles. This finding is more poignant when one considers, along with it, the responses of teacher trainers to items 10 and 13 of the teacher trainers questionnaire (TAMP) which seemed to indicate that teacher trainers were not certain about the objectives of mathematics teacher education in Nigeria or their own role in achieving these objectives.

### **8.3. Levels of understanding of school mathematics by prospective teachers**

Two questions (questions 4 and 5) concerned the level of understanding of school mathematics by trainees at graduation. The motivation for this aspect of the study was,

as pointed out in chapter 1, fuelled by the substantial body of research evidence which suggests that pedagogical content knowledge requires in-depth knowledge of content. Anderson (1989), Scardamalia (1987); Ball, (1990a) and Post et al (1991), for example, have confirmed the importance of strong preparation in one's content area prior to teaching. Unfortunately, the same research also suggest that prospective teachers often do not have adequate content knowledge when they begin teaching. For instance, Post et al (1991) investigated 218 teachers and found that 20 to 30 percent knew less than 50 percent of the contents they were about to teach. Harel (1994) reported similar findings when he tested prospective mathematics teachers on the S&E recommended standards for US teachers.

Although the present study is not a direct replica of either Post et al (1991) or Harel (1994), this researcher was, however, curious to find out whether teachers trained in Nigeria knew enough school mathematics, on graduation, to be able to teach the school syllabus in Nigeria (the NNMC see Appendix A) properly. It was reasoned that such information would also help to determine the relatedness of training curricula provisions to school mathematics subject matter. A school mathematics content test (SMCT), based entirely on the mathematics content of the NNMC, was, therefore, designed and administered to 265 mathematics student teachers just before they graduated. The analysis of the data collected with the SMCT (see chapter 6) revealed a number of interesting results.

First, it was found that only about 70 percent of student teachers tested could demonstrate competence in school mathematics. In fact, 70 percent of prospective teachers knew 80 percent or more of the mathematics they were about to teach in a few weeks time.

This is disturbing, especially if it is realised that the criteria for competence (i.e. 80 percent performance level), used for this study included the average student teacher whose true score was 66.5 (or 76%).

This study, therefore, reveals that prospective teachers in Nigeria, like their counterparts in other countries, do not have adequate knowledge of content when they begin teaching.

If this is correct, and if the proportion is projected to the population of prospective mathematics teachers in all colleges of education in Nigeria at the time when this research was carried out in 1994, over 1500 inadequately prepared teachers (in terms of their level of understanding of school mathematics) could have gone into schools in Nigeria in December 1994 to teach mathematics. The implication for school mathematics over several years is obvious; a considerable number of inadequately trained mathematics teachers (in terms of their level of understanding of the content they were to teach), would have been injected into the primary and secondary school system.

This is not good enough for a country, like Nigeria, which is struggling to come to terms with a number of bewildering new technologies which it had unwittingly embraced. Besides, for a third of entrants to a profession (any profession) in any country to begin their work deficient in as much as one fifth of the knowledge or skill of the profession is, to say the least, a matter for concern. And, if we accept the evidence of research about the role of content knowledge in enhancing pedagogical content knowledge, it is not difficult to conceptualise the implication of this result to mathematics teaching and learning in Nigeria.

This result could not, however, be attributed entirely to the inadequacy of training programmes and should be (and was), for obvious reasons, treated with caution in

making decisions about the outcome of this research; especially in view of what was said earlier about the likely effect, on the initial test instrument, of the corrections made afterwards. Also, one took into consideration the views of teacher trainers on a number of issues. For instance, the quality of intakes; the question of the "massive content" of the training curricular "which encourages rushed work"; time constraints; the effect of trainee's and trainers' apathy towards mathematics teaching as a profession in Nigeria and so on.

Besides these, there is also the possible effect on student teachers of the situation in Nigeria when the test was administered, the very nature of the test itself and the degree of reliability of the test and the reliability of its various constituent sub-tests. Student teachers' performances could have been affected by any of these factors.

One of the findings of the analysis of data from the TAMP is the general problem of finding prospective candidates who are well qualified to train as mathematics teachers. Generally, intakes were said to have weak backgrounds in mathematics and unlikely to benefit from the mathematics components of the programmes, especially as the content analysis also revealed that, in spite of the recommendations of the NCCE, some programmes made no provisions in their packages for courses in school mathematics contents. This is one specific situation where low student achievement on the SMCT could, with some degree of confidence, be attributed to programme inadequacy. Students teachers performed poorly in the SMCT and showed low level of understanding of school mathematics subject matter, probably because, although they had very weak backgrounds in mathematics on admission, they were confronted with higher mathematics for which they were least prepared and, consequently, did not benefit from.

Interestingly, two programmes (F and K), which admit taking students with weak background in mathematics but did not heed the NCCE recommendation to offer compensatory programmes in school mathematics contents, were found to have produced the least proportion of competent graduates from their initial number of intakes.

This, certainly is not an ideal beginning for student teachers contemplating entry to the teaching profession. A prospective school mathematics teacher should be properly grounded in the basics of school mathematics.

The point being made here is that a programme for training teachers, which admits candidates with inadequate backgrounds in a discipline and undertakes to train them as teachers, should endeavour to provide such candidates with an opportunity to upgrade, while still in training, their knowledge of the specific content they are to teach. In other words, teacher educators must take into account the nature of the students for whom the training is planned when deciding on the contents to be included in their programmes. This is the area where, it appears, these programmes are failing the trainees.

Second, the analyses appear to offer some explanation to Omeni (1992) which found that pupils in Nigeria find geometry difficult. Both the difficulty analysis of section 6.4.1 and the analysis of scores on the sub-test in geometry reveal student teacher difficulty with items dealing with this aspect of school mathematics. For instance, only 43 out of the 265 student teachers tested (about 16 percent) were able to demonstrated competence in this content area. Also two-thirds of the items, identified as difficult to student teachers by the difficulty analysis, were items dealing with geometry and trigonometry.

This result is in consonance with Omeni's (1992), which concluded that as many as 86 percent of pupils in Nigeria had difficulty understanding topics in geometry (especially

three dimensional geometry) and that these pupils attributed their difficulty to their teachers' limited knowledge of concepts in the area. Omeni found also that, although it is included in the schools syllabuses, "...the content of three dimensional geometry was hardly ever covered in most schools in Nigeria".

If our finding is again true, it is yet further evidence to support the suggestion that curricular provision for the training of school mathematics teachers in Nigeria may not be related to needs of mathematics teacher trainees. Few programmes offer courses in school geometry and trigonometry although most of their intakes come into training with little or no background in these two areas of school mathematics, the importance of visual and spatial skills (usually, inculcated and developed while learning school geometry) to mathematics learning notwithstanding. This result suggests, also that curriculum provisions in colleges of education in Nigeria are not related to the subject matter of school mathematics syllabuses in that country.

Another finding of the analyses concerns the extent to which student teachers are able to demonstrate certain behaviours. Research has shown that students' learning outcomes can be classified into three interacting groups: thinking, feeling and acting (Bloom, 1956). These correspond to the cognitive, affective and psychomotor domains of learning. Six hierarchical levels of cognitive learning outcomes which relate to levels of difficulty and complexity involved in learning process have been identified. These are: knowledge, comprehension, application, analysis, synthesis and evaluation (Husen, T (ed.), 1967). This order has provided a general guideline for classifying behavioural outcomes in many school subjects. If teachers teach mathematics bearing in mind the demands of these behavioural levels, it is thought that pupils would be able to operate and exhibit behavioural outcomes accordingly

The present study adapted three behaviours from those identified for the International Association for Evaluation of Educational Achievement, which were expected to guide the teaching of mathematics in the classroom. It was hypothesised that, to be able to inculcate these behaviours in their students, teachers must themselves be able to demonstrate them. The SMCT was structured so that student teachers' ability to demonstrate these three skills could also be measured. (see section 4.4.1, from page 88). The idea was to find out which of the three behaviour skills/knowledge prospective teachers in Nigeria are able to exhibit with competence.

The analyses revealed that student teachers were weak in demonstrating process skills and that this weakness is the same whatever programme was employed in their training. This is interesting because WAEC<sup>2</sup> subject reports (e.g. 1993, 1994) on pupils' performances in mathematics at the JSCE<sup>3</sup> and the SSCE<sup>4</sup> had used words and phrases, similar to those used in this study to define this behaviour (see Table 4.5), to describe the factors which, they thought, contributed to pupils' poor results at the SSCE. Could it be that teachers' exhibited level of behavioural outcome is filtered down to their pupils? Because of the reliability estimates of sub-test (see section 6.3.2 and Table 5.4), and what was said earlier about the validity and reliability of those sub-tests, especially the sub-tests used to obtain data on student teachers' ability to demonstrate the behaviour skills, this result is treated with caution.

Finally, the analyses also suggest that there are differences, in the level of subject matter understanding of student teachers passing out from different training colleges in Nigeria. In other words, that competence depends on the college, and consequently the programme, under which a student is trained. Programme A was shown to be better

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<sup>2</sup> West African Examinations Council (WAEC).

<sup>3</sup> Junior Secondary Certificate Examination (JSCE).

<sup>4</sup> Senior Secondary Certificate Examination (SSCE).



than other programmes in this respect. Two programmes, F and K were found to produce the lowest percentages of competent student teachers, especially in geometry and trigonometry, from their respective intakes.

Again, as pointed out earlier and for more reasons explained in section 9.5 (Limitations) in the next chapter, this result must be regarded as indicative rather than definitive. Other factors, not investigated because they are not the subject of focus in this study, may have contributed to this.

#### **8.4. Relationship of curricular provisions to school mathematics and to the needs of trainees**

The last question of this research, (question 6) is about the relationship between teacher training curricula in Nigeria and the needs of student teachers who are expected to implement the school curriculum on graduation. The question is concerned with the issue of the different total training packages which student teachers of mathematics go through in the course of their training in Nigeria; particularly, provisions in the programmes for inculcating certain teacher essential knowledge components which are generally acknowledged as essential for mathematics teaching.

The discussions in the preceding sections provide some clue as to the direction of the answer to this question. However, the analyses provide further evidence to suggest that the training packages are not particularly informed by research on teacher education nor by a proper consideration of recognised fundamental issues in programme design; and that consequently training curricula for mathematics teachers in Nigeria may not be related to school mathematics or appropriate for the needs of prospective teachers.

Research on teachers' knowledge identifies some knowledge components which are, generally, considered essential for the teaching profession. These components were

sorted out for the purpose of the content analysis into six categories: knowledge of content, knowledge about content, pedagogical content knowledge, general pedagogical knowledge, context knowledge, and practical skills.

This study has argued that each of these components is critical for teaching, especially for mathematics. This is because the first three components represent generally accepted intuitive notion of the qualities required of a good teacher: the teacher must have something to teach (content knowledge) and must know how to teach it (pedagogical content knowledge). The fourth component represents this researchers' agreement with the general view of recent studies which have recognised the complex nature of the professional knowledge required of a teacher and has, thus, sought to distinguish between pedagogical knowledge/skill specific to the subject matter of a discipline and pedagogical knowledge pertaining to the teaching profession in general; both of which are considered important for good delivery of a lesson in any discipline.

Context knowledge was used, in this study, to represent those aspects of pedagogical content knowledge which require the use of the kind of knowledge peculiar to, or embedded in, the culture of a specific society/environment to enhance pupils' understanding of contents; distinguishing it from that aspect which requires the illustration of the subject matter of a discipline by using a collection of methods that have been tried and handed down by "master teachers" in that discipline. The importance of this knowledge component to mathematics teachers, especially to teachers in societies with diverse population which adopted western style education in place of their indigenous education system, is highlighted in recent studies (e.g. D'Ambrosio, 1995, Nunes 1992) on the influence of culture on mathematics teaching and learning. Nunes (1992), for instance, show how they influence the acquisition of

certain mathematical concepts and skills, especially in the primary and junior secondary stages.

The analysis of programme content sorted training curricular provisions according to which of the six knowledge components it was thought each course, on offer in a programme, aims to inculcate. The rationale was that a training programme which relates to the needs of teachers should provide courses that aim to inculcate these essential knowledge components; and, if a training programme relates to school mathematics and to the needs of the trainee, any product of it (prospective teachers) should be able to demonstrate (e.g. on a test such as the SMCT<sup>5</sup>) the minimum level of understanding (e.g. our criterion for competence) of the subject matter of school mathematics

The content analysis of chapter 5 revealed, first, that two very important sub-categories of pedagogical knowledge specific to mathematics teaching and learning (“psychology of mathematics teaching and learning”, and “assessment and evaluation in mathematics”), are either glibly treated or completely ignored. This is surprising; educationists must know that teaching largely involves, among other things, the assessment and evaluation (formative and summative) of the curriculum and the pupils at various stages of development. Also, the immense contributions of psychology to mathematics teaching and learning are well recognised within the education community all over the world.

Second, despite the fact that there are diverse cultures and subcultures within Nigeria and variations among these cultures in, for instance, numeration systems used or beliefs that affect the choice of what is to be taught in schools and how they are to be

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<sup>5</sup> Context knowledge, in the sense in which it is conceptualised in this study, was not tested because, although it is an essential component of teachers’ knowledge, it does not appear as a content area of the NNMC on which the SMCT is based. The aim of the SMCT was purely to ascertain student teachers’ level of understanding of the subject matter of the NNMC. Anything otherwise is outside the scope of this study.

presented (see section 3.5 of chapter 3), there are no courses on offer in any of the programmes that are aimed at making teachers formally aware of the types of cultural beliefs, activities and knowledge within the society that are likely to influence (enhance or otherwise) the teaching and learning of mathematics in any way.

It is realised that all colleges of education are required by the federal government, through the NCCE, to provide courses on what is referred to as "Nigerian Peoples and Culture" (see sections 3.7 and 5.2 of this thesis); but closer examination of the contents of these courses show that, in all cases, they are of a general type; dealing with the history of the different communities in Nigeria, their cultural values, their different religious practices and so on - nothing like, say, the different numeration systems, counting and recording procedures, measuring units, calculation methods or even the way they approach solutions to problems; all of which, although not specifically mentioned in the school syllabuses, are present in everyday activities about the home in Nigeria; which, if properly integrated into classroom activities, could be utilised to promote pupils' awareness and understanding of various mathematics concepts. For instance, the numeration system of the Ibos, which is based on multiples of twenty and sixty, could be used to explain the idea of counting bases and hence addition of times in the twenty-four hour clock system. Also, the Yoruba numeration system which relies on alternating adding and subtracting different values, depending on whether one is approaching multiples of ten which are also multiples of twenty or other multiples of ten, could be used to promote clearer conception of multiplication as continuous addition and division as continuous subtraction.

Third, the specification of course contents on offer by the training programmes reveals that their curricula were basically developed from a substantial synthesis of content materials from the core mathematics courses of the first (and in some cases second)

year undergraduate mathematics courses of the validating universities. This is hardly the best approach to designing a training programme for prospective teachers of mathematics in primary and/or secondary schools. By simply adopting mathematics courses of the validating universities, college programmes failed to take conscious account of important basic issues and, thus, missed an important aid in design and implementation of programmes.

Fourth, provision was not made (through adequate courses or, for instance, an assessment based on the contents of school mathematics) to ensure that, after training, a teacher was sufficiently equipped to teach the subject matter at the intended level: primary and/or junior secondary schools. These suggest that, in formulating a framework for designs for programmes for the education of teachers in Nigeria, proper consideration may not have been given, as is standard practice, to the objectives of the training, bearing in mind the context in which the final product of training is to work.

The analysis of questionnaire responses from teacher trainers provides further evidence for this. Perhaps, the most basic process in the design and implementation of training programmes require decisions to be made about *what* and *how*, about content and methodology. The “what” part is usually met by detailing contents based on a clear definition of the objectives of the programme. The “how” part, besides mentioning the method(s) to be used etc., includes a statement about the quality of personnel that are likely to implement the programme successfully and, thus, achieve the intended objectives of the programme.

The analysis of data from the teacher-trainers’ questionnaire in chapter 7 reveals that an appreciable proportion of those put in charge of mathematics teacher training in Nigeria (the lecturers) know very little about the objectives and philosophy of mathematics teacher education. This is not surprising because the same analysis also reveals that a

substantial proportion of the teaching force in mathematics departments of colleges of education in the country is made up of non-graduates or graduates without proper training or no training at all in education. Over 71% of trainers, most of whom admitted to being dissatisfied with their jobs as teacher trainers, were also found to have had no pre-college of education teaching experience, say in the primary or secondary schools system.

This is a clear recipe for non-performance. There is unlikely to be any correlation between the aims and objectives of the programmes and the performance of such lecturers in the lecture rooms. It is also unlikely that they will be well-placed to either identify or deal with the needs of trainees. It is not surprising that most of the trainers were unable to mention one feature of their training that could enhance the trainees' effectiveness.

Teacher trainers were also shown to have poor perception of mathematics teachers' programmes in their respective institutions to the extent that up to 53% believed that programmes under which mathematics teachers are trained are inappropriate.

Analyses of results suggest, therefore, that programmes for the training of school mathematics teachers in Nigeria are not appropriately targeted to the needs of the student teachers nor to the needs of the school system for which the student teachers are being trained.

### 8.5. Findings

In summary, this study revealed that:

1. There are differences between programmes in entry requirements to colleges of education in Nigeria to train as a mathematics teacher. Final selection depends largely on review of paper qualifications.
2. There is a contradiction between stated aims (in terms of the destination of student teachers after their training) and curricular provisions (in terms of planned courses).
3. There are disparities among programmes in the requirements for final certification.
4. There are inconsistencies and differences within and between programmes in the weighting of courses, in terms of the number of credits allocated to courses in a programme or similar courses in different programmes.

The above four findings make it difficult to determine the standard of, or to accord equal status to, the initial teacher qualifications (i.e. the NCE certificates) awarded by different colleges of education in Nigeria.

5. The level of understanding of school mathematics by prospective teachers in Nigeria is low. Over 30% of student teachers were found to have understood less than 80% of school mathematics contents.
6. The level of understanding of school mathematics by prospective teachers depends on the programme under which a teacher was trained.
7. Some programmes (particularly programme A) appear to be more efficient than others in turning out, from their initial intake, prospective teachers with acceptable level of understanding of school mathematics contents. Programmes F and K stand out as the least effective in this respect.

8. In general, prospective teachers in Nigeria have difficulties understanding the contents of school geometry and trigonometry.
9. It is likely that prospective teachers in Nigeria, in general, have difficulty solving problems which require substantial use of process skills. However, a more valid and reliable test than the SMCT is required to confirm this finding.
10. There is a mismatch between training provisions and the needs of initial student intakes.
11. Programme designs may not have been informed by research, particularly in their selection of courses for the mathematics component and pedagogical knowledge specific to mathematics.
12. And finally, neither the overall sample of student teachers tested nor any group of student teachers in any programme group met the criterion for an affirmative answer to the two questions (questions 3 and 6) about the relatedness of training curricular to school mathematics contents or to the needs of trainee teachers.

As a consequence, it appears that

13. In general, curricular provisions in colleges of education in Nigeria, are not related to the subject matter of the school mathematics syllabus in Nigeria nor to the needs of student teachers for whom the training is meant.

Some conclusions have been reached, based on these findings, about the specific questions asked in this study. These, together with suggestions for improving mathematics teacher education programmes in colleges of education in Nigeria, are presented in the next chapter.



## CHAPTER 9

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### CONCLUSIONS AND RECOMMENDATIONS

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#### 9.1 Introduction

In this final chapter a brief review of the problem and purpose of the study is presented; followed by the conclusions reached. Recommendations and suggestions, for improving teacher education programmes in Nigeria, are presented in section 9.4. In section 9.5 problems and limitations associated with educational research of this kind are discussed. Suggestions for further research in this area complete the chapter and the thesis.

#### 9.2. Restatement of the problem and purpose of the study

The main thrust of this research was to find out the practices that went on in the training of teachers of school mathematics in Nigeria. In 1973, Nigeria introduced universal primary education and between 1960 and 1992 she embarked on a massive expansion of her educational provision at other levels in order to meet the demands of her new status as an independent sovereign state. But because the expansion was not properly handled two problems emerged. First, there was an acute shortage of trained teachers for the new schools and second, students' performance in nearly all subjects at public examinations declined (see, for instance Denga 1992). The decline was noticed more in mathematics because of the importance attached to the subject by both the society and the individual. It is needed for progression to higher education and for entry into all aspects of training or employment.

The federal government acted to combat the shortage of teachers by calling on individuals, local communities and state governments, where they could afford it, to establish colleges of education of their own. It further promised very attractive financial incentives to such private proprietors. This resulted in the proliferation of colleges of education, many of which were teacher training institutions only in name. Even up to 1992, when it was apparent that the problem of shortage of teachers was nearly overcome, students' performance in mathematics (and indeed other subjects, especially the sciences) continued to deteriorate. This prompted public opinion (as always in such situations), which was convinced that the problem lay with teaching standard, to call for government control, adequate planning and improvement in the quality of teacher preparation in the country. The claim was that because the expansion in teacher education had been rushed, uncontrolled and largely unsupervised, these institutions were turning out graduates who were not properly equipped to teach the subject matter of various Nigerian national curricula for schools, especially the Nigerian National Mathematics Curriculum (NNMC).

This research was initiated as a reaction to that claim. The researcher, who was a lecturer at a college of education in Nigeria, wondered whether this claim was, in fact, true in respect of prospective secondary school mathematics teachers. What programmes were in place for their training? How well did they understand the subject matter of the NNMC at the point when they were about to be sent out to teach that syllabus?

To shed some light on some of these questions this study examined and analysed 12 randomly selected mathematics teacher training programmes from colleges of education in Nigeria in terms of six components of a teacher's knowledge, which have been identified by research as essential for the craft of teaching: knowledge of subject matter,

knowledge about subject matter, general pedagogical knowledge, pedagogical content knowledge, context knowledge and practical knowledge. These components were used to define categories of essential contents of a mathematics teachers' training programme. The categories were further divided into twenty-five sub-categories of content.

A content checklist was then used to gather data which could be used to answer the first three of the six specific questions of this research, which it was thought needed to be explained before a statement about the mathematics teacher education programmes in the country could be attempted. These were questions about: (a) existing conditions (e.g. admission requirements, duration, scheme of studies, evaluation and assessment procedure, certification requirement, and so on), (b) contents (activities and experiences) in programmes for teacher training; (c) differences/similarities in curricular provisions at different institutions; and (d) the relationship between curricular provisions and school mathematics content. The data collected, with the checklist, were presented and analysed in chapter 5.

Furthermore, because of the contemporary concern in Nigeria and indeed all over the world (for instance current debate about standards in mathematics in UK, etc.) about content knowledge of prospective teachers, it was decided to find out whether the outcome of research in other countries concerning the level of understanding of school mathematics contents by prospective teachers was also true of prospective teachers in Nigeria. Student teachers' level of understanding of the subject matter of the school mathematics syllabus in Nigeria (NNMC) was, therefore, tested using a school mathematics content test (SMCT). The SMCT was constructed based entirely on the mathematics content of this syllabus and was administered to 265 student teachers

selected randomly from all colleges of education in Nigeria. The data collected with the SMCT were presented and analysed in chapter 6.

The specific questions which the SMCT sought to answer were those concerned with competence, after training, in the subject matter of a discipline (mathematics). In other words: how well do student teachers passing out of colleges of education in Nigeria understand the subject matter of a mathematics syllabus which they were about to teach.

It was hoped that armed with this information the researcher would be in a position to make a statement about student teachers' levels of understanding of the subject matter of school mathematics and, perhaps, be able to shed some light on the quality of the training received by student teachers in colleges of education in Nigeria.

Also a questionnaire was administered to teacher trainers in order to solicit their views about mathematics teacher education programmes in Nigeria. It was hoped that, together with other results of this study, this information would help the researcher to reach a sensible conclusion on the question of the relationship between training curricula and school mathematics curriculum and between training contents and the needs of trainee mathematics teachers.

### **9.3. Conclusions**

From the findings of this study (see section 8.5 of the preceding chapter), there is substantial evidence to show that:

1. Programmes that exist in Nigeria for the training of school mathematics teachers may not be achieving the intended objectives because:

- a) there is a contradiction between stated aims (in terms of the level of the school system for which training is being provided) and the training provisions (in terms of the type of courses offered);
- b) there is a mismatch between curricular provision and the mathematical needs of intakes to the programmes;
- c) programme contents appear not to be related to the subject matter of school mathematics nor to the needs of trainees;
- d) programme designs appear not to be informed by research, particularly in the area of knowledge essential for mathematics teaching.

2. In general, the level of understanding of school mathematics by prospective teachers in Nigeria is low. A substantial number of newly qualified teachers in Nigeria could not be relied upon to teach the subject matter of the Nigerian National Mathematics Curriculum (especially the geometry and trigonometry components) with confidence.

3. The Nigerian Certificate in Education (NCE) awarded to mathematics student teachers after their training by different colleges of education in Nigeria cannot be said to be of the same quality because of the differences in curriculum content, method and mode of training, quality of their intakes and above all the disparity among colleges in the requirements for final award..

4. There appears to be low understanding, among teacher trainers, of the objectives and philosophy of mathematics teacher education in Nigeria. Most teacher trainers described the objectives in terms only of ability of the student to solve abstract problems and believe that the main purpose of training is to help student teachers develop enthusiasm and intellectual ability for further studies in mathematics.

In the light of the above conclusions the following recommendations are made.

#### 9.4. Recommendations

It appears that the specific future needs of prospective secondary school mathematics teachers in Nigeria are not served by the type of training that is available for their training in colleges of education in Nigeria at the moment. This view rests specifically on findings related to three aspects of the present study. First, the quality of candidates available for training; second, the level of understanding of content exhibited by prospective teachers and third, the relationship between stated aims/objectives and curricular provisions.

Teachers need to understand the significance, mathematical and real world, of the mathematics they are teaching, and it is in the nature of the dynamics of good mathematical instruction that this understanding comes from studying the sequels to that mathematics; thus, for the secondary school teacher, from studying undergraduate mathematics, especially the core curriculum. Also, the teacher's mathematical understanding must always go beyond the level at which he or she is teaching, in order that the teacher be confident to present new materials, to encourage questions, and foster experimentation. The only good teacher is one who welcomes divergent trends among pupils; convergence, which leads to easy classroom management and sterile atmosphere, is the refuge of the teacher devoid of in-depth knowledge, fearful of finding himself or herself out of his or her depth.

However, it is doubtful whether we can ever attract quality candidates to train as mathematics teachers if the present policies, which teacher trainers claim discourage candidates from seeking to take mathematics teaching as a profession, are not reviewed. The low quality of entrants to mathematics teacher training institutions in Nigeria will not allow the type of good teachers that we described in the preceding paragraph to emerge. It is even doubtful, if the present system, which allows

mathematics teachers to be trained away from other mathematics majors, in special colleges of education, could ever encourage the right calibre of students to seek admission to train as mathematics teachers.

On the other hand, appropriate training programmes could be designed to take into consideration the needs of entrants to training. But to achieve this requires a high calibre of teachers educators or curriculum developers. To attract such high quality personnel demands attractive incentives which, in turn, would mean a change in the policy that results in a situation in which teacher trainers to feel dissatisfied with their job (as they showed in their responses to the TAMP).

Mathematics teacher education in Nigeria, therefore, needs to be modified in at least three aspects:

- review of admission policy and requirements;
- review of training programmes to reflect the needs of potential entrants and those already in the field;
- improvement in conditions of service of teaching personnel in colleges of education to encourage quality and retention.

The author would, therefore, like to make the following recommendations.

#### *Admission policy and requirements*

The admission of candidates to be trained as teachers of mathematics must be based on some sound policy and selection processes that ensure the admission of suitably qualified candidates. It is suggested here that while it is necessary to place emphasis on candidates possessing sound foundations in the basic pre-requisite concepts in school mathematics, the interest and aptitude of the candidates must not be neglected. This points to the invaluable involvement of interviews in the final selection process of candidates. But, how does one get over the lack of supply?

Also, in order to attract more competent candidates, it might be necessary to change the attitudes of both the public and the educational system towards mathematics by, for instance, taking steps to dispel the fears associated with the subject in the society. It is realised that both recommendations are not easy to implement, but we can start reviewing the general policy relating to the treatment of and status accorded to mathematics teachers in Nigeria so that well qualified candidates are attracted to train to teach mathematics.

#### *Review of training programmes*

There should be an immediate review of mathematics teachers training programmes in the country to project a notion of mathematics that sees the subject in its unity and essence as a discipline; not a set of skills (though its practice requires and inculcates skills), nor a set of separate disciplines that could be put in compartments such as is evidenced in the programmes that were analysed in this study.

And because of the low mathematics background of potential intakes, secondary content courses, that aim at reviewing thoroughly the mathematics that is basic to the topics in the secondary school syllabuses, should be included. The aim should, however, be to expose the future mathematics teacher, not just to disjointed courses in some areas of mathematics, as is presently the case with some programmes that offer secondary contents, but a single unity comprising many interrelated areas of study. For example, that algebra at the secondary level (that is, until abstract algebra is encountered) is simply arithmetic made mathematical - arithmetic expressed in an appropriate mathematical language. This language leads to systematic procedures for getting answers to mathematical questions, but it is unlikely to lead, of itself, to the formulation of natural, interesting questions. Such questions arise from modelling the real world, very often mediated through geometrical presentation. An aspirant to



mathematics teaching should, thus, understand that it is a fundamental pedagogical blunder to teach algebra or geometry in isolation. An exclusive diet of the former produces boredom, of the latter, frustration. There are other examples to illustrate what is meant here; for instance the link between calculus and the real number system with its several interrelated structures, and so on.

Secondary contents courses should, also, deal with contemporary beliefs in the nature of mathematics, history of mathematics and those other aspects of the content knowledge that were described by Ball (1990a) as constituting knowledge *about* mathematics subject matter. Every prospective school mathematics teacher should be encouraged to take these courses while in training. Courses in pedagogy should then be carefully co-ordinated with these courses.

Perhaps, the most difficult issues in undertaking such a review are decisions to be made about *what* and *how*, about content and methodology. For instance, in mathematics teaching there has been much debate, in recent years, about what the content of a teaching programme should be. Should the syllabuses be prescribed or negotiated? What are the elements of which they should be composed? How are these selected and graded? Are courses of a pedagogical nature important in teacher education? The answers one arrives at will be different in particular circumstances, but the issues are constant.

However, a specification of intermediate and terminal objectives for mathematics education is now an accepted part of good programme planning. Their value is seen as two fold: firstly they act as a chart to student teachers of their progress through the course and an incentive in terms of setting an attainable goal; secondly, they help to reduce, for the trainer and the trainee, the infinite possibilities of mathematics into something more tangible and realisable. What the objectives of a particular programme

should be cannot be pre-judged in vacuo and indeed may be amended as the training progresses. But there should be objectives and these should be clear to student teachers and teacher trainers.

An objective, which must be the fulcrum upon which the rest must be hinged, is the inculcation of the knowledge essential for effective teaching. The results of the analysis, in chapter 7, of responses to the questionnaire revealed that teacher trainers in Nigeria did not fully comprehend the importance of this or other similar objectives.

The federal or state ministries of education, the universities and all colleges of education should, therefore, organise a panel of mathematics experts to study and review the existing programmes with a view to developing programmes that will be suitable for the training of school mathematics teachers that Nigeria needs. The author recommends that this panel includes members of the committee that designed the present secondary school mathematics syllabuses.

#### *In-service training (INSET)*

Initial training programmes, whatever their merits, however marvellous their curriculum provisions may be, and whatever their duration, cannot by themselves alone be expected to equip a teacher with all the qualities needed for good teaching in any discipline. This is why another recommendation of this research is that the review of existing programmes, in the manner suggested above, should be accompanied by properly planned in-service workshops for mathematics teachers already in the field. This is important in the light of the implication, to school mathematics education, of one of the findings of this research; that prospective teachers have low understanding of content. If it is accepted that as much as a third of newly qualified teachers in 1994 (when the field work for this research was carried out) lacked adequate knowledge of school mathematics, then it is only reasonable to conclude that, since nothing changed

or has been changed to improve the situation, the same was the case over the years before and after 1994. The implication is that a good number of teachers already in the field lack adequate content knowledge. We cannot, therefore, start to arrest the decline in pupils' performance in mathematics unless we tackle the problem of the competence of teachers already in the field. More workshops and in-service programmes need to be organised to make those secondary mathematics teachers already in the field aware of the content and requirements of new syllabuses and conversant with pedagogical demands of the new topics and concepts.

It is known (Chapter 3, for instance) that teachers' pedagogical skill continues to develop with experience but that knowledge of content is not always so enhanced; especially if it was not properly inculcated, in the first instant, during training. Properly planned INSET programmes that emphasise content knowledge is thus necessary as a matter of urgency.

#### *Practical components of training*

One of the disparities between existing programmes, revealed by this study in the training of mathematics teachers in Nigeria, is in the manner in which practical teaching is organised and carried out. It was pointed out that apart from the inconsistencies found in the way this component was weighted in different programmes, the exercise itself was faulty and inadequate in more than one sense.

Teaching is undeniably a practical activity and, as such, requires that the practitioners develop practical skills in addition to theoretical insights. In this connection one was concerned that the systems in operation in most colleges (in which students go out into schools for only 12 weeks in their three years of training) do not afford student teachers sufficient experience in the classroom to allow them to develop, test, revise and expand their practical skills.

The scheme being operated by colleges using programmes F, H, and K do not, in my view, solve the problem either, since it runs the serious risk of minimising the time spent on developing subject knowledge, with the consequent danger of producing highly skilled teachers who have a weak knowledge of what they are to teach - a situation found by Adepoju (1991) to exist among teachers already in the field, who were trained in the old TTCs in Nigeria.

There are several ways in which this problem might be overcome, not all of which have equal merit. The first might be to have more contact with local schools and either bring a class of children from one of the schools into the colleges for a whole day during which they would move from department to department to receive their lessons from student teachers. These lessons, and student teachers who teach them, would then be guided, supervised and regulated by lecturers at the college. This would go on throughout the three years of training.

A second option, which could perhaps be seen as being complementary to the first, would be to take student teachers from a given subject department (in this case mathematics department) into schools in small groups, introduce them to a class and let them teach that class between them for a term. They could either adopt a team teaching approach (where appropriate) or one student teacher could teach a lesson while his/her colleagues observe and criticise him, possibly using the same format as that used by lecturers to assess teaching practice performance at the moment. The next lesson would then be taught by a different member of the team and so on. This would be done, at least, once a week throughout the duration of the training.

The third suggestion reflects the practice adopted by many universities in the country when dealing with undergraduates in modern language departments. Undergraduates are required to go and live for one year in the country whose language they are

studying. In the case of mathematics student teachers, after having spent two full sessions in college, they could go out into the field (schools) for one session. During this year, they should be supervised and guided both by a college of education staff and by an experienced mathematics teacher in the co-operating school. Student teachers should be required to collect data for short dissertation which should be compiled and presented on their return to college, for a fourth session of their course. This fourth year would afford them an opportunity to thoroughly debrief themselves of their individual teaching experiences under the guidance of their lecturers and afford them more time to develop subject knowledge.

The final suggestion involves revitalising something which existed before in Nigeria: confirmation of appointment. If during the first one or two years of their teaching career, newly qualified teachers were more closely supervised by the staff of the training institution or their employers, than is the case at the moment, they would be able to continue to develop their practical skills *under guidance*. If one's development during this period is satisfactory one's appointment can be confirmed, otherwise, the period of probation could be extended, to enable one to make the grade, or the appointment could be terminated. The probationary period can be seen as the equivalent of the period of "housemanship" required of doctors or the period which accountants or lawyers spend articulated to established firms of accountants or solicitors before they can go out and practise on their own.

#### *Materials and teaching personnel in colleges of education*

In Nigeria the role of teacher training could be said to rest ultimately on the universities. Universities validate programmes used in colleges of education. At the same time, they supply teacher trainers to colleges of education. Unless Nigerian universities address themselves to the question of producing qualified mathematics graduates for the training

institutions, the country will continue to face the problem of non-graduates teachers teaching mathematics and mathematics education in colleges.

Most lecturers in colleges of education were found not to understand, properly, the objectives of teacher education or able to mention features of their training programmes that is most important in enhancing the efficiency of their students. This is inadequate.

It is, therefore, recommended that universities endeavour to equip intending teacher educator to be able to:

- set up a goal for themselves in educating mathematics teachers for secondary schools; evaluate their knowledge of and competence in mathematics in light of curriculum requirements of courses they teach and of recommendations of professional groups; determine the further study (formal or informal) they need to increase their competence; have sufficiently positive attitudes and a good academic background to be able to learn appropriate further mathematics and to relate the advanced information to increasing their effectiveness as lecturers;
- relate the new mathematics they study and discover to the level of mathematics they are teaching; help their students teachers understand human development and the nature of learning mathematics sufficiently well so that they are able to recognise how existing conditions are related to learning and how models of teaching use and change these existing conditions; to understand such models as concept attainment, inquiry training and group investigation and to recognise under what condition each is most effective;
- help their students gain sufficient knowledge of the variety of cultural backgrounds from which children in schools originate in order to be sensitive

to variables affecting the learning processes of children of different ages, ethnic backgrounds, languages, geographic origins and living conditions;

- help their students teachers gain sufficient knowledge of the history of education and mathematics and of the institutions in one's society, to be aware of the decisions made at local, state and federal levels that influence a teacher's capacity to teach mathematics well and to determine the nature of that influence;
- Use appropriate texts in order to continually re-evaluate their own philosophy and competencies; to diagnose the variations in the learning abilities of each of their student teachers and then prescribe for each student teacher appropriate learning materials, laboratory experiences, sources of information, sources of supporting help, and processes to be used to meet the student's need in each section of mathematics.

On the support material or facilities for teaching mathematics the following recommendations are made.

- Relevant text material for the lecturers and trainee's guides for the teacher training curricula should be produced and made available to the institutions; especially for the NCCE curriculum guidelines.
- Government should make more finances available for the procurement of essential facilities, texts, and guides which the individual student teacher find quite difficult to procure because of the prohibitive commercial prices.

Remuneration and conditions of service for lecturers' and school teachers' must never be ignored or trivialised, as has been the case in recent years. These two are very important factors that affect the zeal and morale of the teacher in his job performance.

An observation made by Efa in this respect and quoted in Bajah (1993) reads:

"Teachers have seen a massive decline in their status they are asked to work long hours for a salary that has rarely kept up with inflation; they often work with only a few materials of very poor quality; contact hours with their students are reduced; and more and more time is spent on needless administration brought about by constantly changing government policies."

In summary, it must be concluded here, that no effort should be spared in the proper training of mathematics teachers both at the initial and in-service stages. Desirable competencies of a mathematics teacher have been exhaustively discussed in chapter 3. Enough well-qualified teachers, it is said, are a sine qua non of successful curriculum implementation, as no curriculum material is teacher-proof. Deliberate effort must, therefore, be made to familiarise teachers with the nature, development and history of the subject they are about to teach, different views (or beliefs) about the subject and materials they are expected to use in the class room. Experience has shown (see for example, Lassa, 1992) that no matter how well an education programme has been developed, the success in the final analysis depends on the classroom teachers. Their training are, thus, crucial.

Finally, based on a careful consideration of the findings of this research, the author has here shared with the reader some thoughts on what he felt were some areas of concern for the mathematics training of secondary school teachers in Nigeria. Most of them were directed at services the mathematics education community must render to individual secondary school teacher. The author has made no pretence that this list of suggestions is all-inclusive. He may well have missed the reader's own favourite issue. Though personal bias and hopes for certain developments are reflected in some of the commentary, he has no intention to propose solutions to every issue.



### 9.5. Limitations

The fieldwork for this research was undertaken during the most critical point of the political crisis in Nigeria (see section 4.1 of chapter 4), which did not guarantee the nominal condition for data collection. Programmes were chosen because colleges that offered them were accessible to the researcher and were, therefore, easier to obtain. It was possible that these programmes differed systematically from those that were not analysed. It is likely, therefore, that any of the findings of this study could not be generalised for all colleges of education in Nigeria.

Also, for the same reasons, a completely random sampling of students teachers for this study was not possible. The study relied on the co-operation of individuals and institutions. In some cases, heads of departments of mathematics in some of the 53 colleges made the selections and sent names of student teachers to the researcher. This, coupled with time and financial constraints, meant that the data collected was influenced by the degree of reliability, to sample randomly, of some co-operating heads of departments. This is bound to introduced another threat to the validity of the findings. Hence, much more caution was and should be taken in interpreting some of the findings; with a consequent limited application and implication of such findings for the whole country.

A number of critical comments about the use of multiple-choice test as a measure of achievement or behavioural skill have been made. Among the criticisms are the crudeness in the construction and validation of the test, the difficulty posed by the reliability of the test, the inadequate control of extraneous variables which could have influenced performance or failure to use inadequate measures of gains, the

susceptibility of multiple-choice test to be influenced by luck (guessing). This study falls into the same categories for criticism.

Although there are queries about the validity of measures of content competence, the fact remains that a number of techniques, similar to the SMCT, are available and have been used to measure achievements, even though they are not exact measures. But since the usefulness of results is frequently limited by the precision with which outcomes were measured, it is accepted that something need to be done to improve both the validity and reliability of the SMCT. The criterion measures used were, however, reasonably satisfactory and certainly up to an acceptable standard in the circumstance. The results of this research could reasonably, therefore, be relied upon in most respects.

The use of an index of statistical significance, as a criterion for judging that a difference was worth attending to, presents all educational researchers with serious difficulties. A study with great statistical power can be designed merely by including large numbers of students and classes in each group. If any differences exist at all, no matter how small, a sufficiently powerful design would show statistically significant results. Yet these results might be of no theoretical or practical value whatever. Even with the most efficient mathematical model to answer questions, the problems of the educational significance of the criterion chosen would remain. Unhappily, the researcher followed the established precedence of accepting the criterion of statistical significance and hoped for the day when results would be reported and compared in a different way.

Notwithstanding these difficulties and limitations, the results of this study depict the typical situation in Nigeria and, at least, provide a reference base needed at the moment in Nigeria for future/further research in mathematics teacher education. This way it would have contributed to mathematics education by providing mathematics teacher

educators, in Nigerian, with insight into proper understanding of the state of mathematics teacher education in that country.

The one caution that is sounded is that care must to be taken in extending the results to other countries because of the likely differences in regional variations. For example, training programmes in other parts of the world may vary according to local traditions and facilities. The results should, however, be useful for reference and comparisons since their interpretation is informed by the literature review.

### **9.6. Suggestion for further research**

This investigation has brought to light a number of problems in the area of mathematics preparation of secondary school teachers. It might be necessary to conduct follow-up studies on the following issues in the same area.

1. A case study of some programmes (e.g. programme A), found in this study to be more efficient than others, under actual classroom situation may prove profitable.
2. An accurate picture of the required curricula for pre-service training of school teachers in terms of specific experiences for students ought to be obtained. Such a study must include a detailed analysis of at least the most frequently required courses.
3. Studies might very profitably be made of the academic requirement for certification. One phase of the investigation might well deal with the correlation of such requirements with actual need for such learning on the part of secondary school mathematics teachers.
4. Better evaluation instruments and techniques need to be developed in order to more adequately check students' growth towards the goal of the secondary school teacher.
5. This investigation studied only pre-service teachers as a group. It is suggested that some research into the level of competence of teachers already in the field would be a valuable addition to this area of knowledge.

The studies are to be undertaken with a view to gaining more information on the usefulness of the training. The information gained will not only serve as relevant indicators of the success of the training but will also provide useful data for any possible over-hauling of the curriculum and the training materials.

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APPENDIX A  
THE NIGERIAN  
NATIONAL  
MATHEMATICS CURRICULUM (NNMC)

APPENDIX A-1

# MATHEMATICS

CURRICULUM

FOR

JUNIOR SECONDARY SCHOOLS



Y E A R O N E

Note: Throughout, the statement of objectives are written in terms of what is expected of the students at the end of the learning instructions.

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
A. Number & Numeration	<ol style="list-style-type: none"> <li>Students will be familiar with some common number systems.</li> </ol>	<p>An indigenous system of special relevance locally.</p> <p>The Roman System</p> <p>The abacus as a calculating machine.</p> <p>Brief history of the spread of the Hindu-Arabic system.</p>	<p>Research into local counting and reckoning systems including writing of essays and reports, e.g. market days, week-days.</p> <p>Refer to some practical uses e.g. clocks, book chapters.</p> <p>Construction of an abacus and the use of it.</p> <p>Comparison between a place value system and an additive system.</p> <p>writing coded messages based on A=1, B=2, C=3, etc.</p>	
	<ol style="list-style-type: none"> <li>Students will be able to identify and solve problems involving basic arithmetic processes.</li> </ol>	<p>Revision exercises in addition, subtraction, division and multiplication.</p> <p>Place value</p> <p>Diagnostic tests</p> <p>Word Problems</p>	<p>Diagnostic tests should be used to identify specific weakness so that remedial teaching can be given as necessary.</p> <p>Accurate records of each student's performance should be kept.</p>	<p>A thorough knowledge of place value is fundamental to an understanding of the basic operations. It is vital to achieve a high level of computational skill based on sound knowledge of principles.</p> <p>Multiplication and division by numbers less than 1000 only.</p>
	<ol style="list-style-type: none"> <li>Students will be able to apply the basic arithmetical processes to common and decimal fractions.</li> </ol>	<p>The law of equivalence of common fractions. Basic processes applied to common fractions. Basic processes applied to decimal fractions. Relation between percentages, common and decimal fractions.</p>	<p>Illustrate equivalent fractions, common fractions and percentages using squared paper and paper folding. Emphasise the inter-relations between the different fractional systems e.g.</p> $0.2 \times 1.5 \text{ is identical to } \frac{1}{5} \times 1\frac{1}{2}$ <p>and <math>\frac{3}{4} = 0.75 = 75\%</math></p>	<p>Decimal fraction should be largely confined to two places.</p> <p>Note: <math>0.5 + 1.27</math> is unsound mathematics and should be presented as <math>0.50 + 1.27</math></p>

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>4. Students will be able to:</p> <ul style="list-style-type: none"> <li>(i) identify,</li> <li>(ii) add,</li> <li>and (iii) subtract</li> </ul> <p>the integers.</p> <p>5. Students will be able to estimate value of articles and other measures used in everyday life.</p>	<p>Addition and subtraction of positive and negative integers. Everyday applications involving positive and negative integers. Use of the number line.</p> <p>Range of cost of various articles.</p> <p>Dimensions, capacity, mass of everyday articles, local distances, personal statistics of people.</p>	<p>Walking forward and backwards or upstairs and downstairs.</p> <p>Temperatures above and below zero.</p> <p>Banking—deposits and withdrawals.</p> <p>Drawing of points on the number line and using them for positive and negative additions.</p> <p>Students should be given a list of everyday articles and be required to write down approximate prices, e.g. box of sugar, cubes, measure of rice, plastic cup, pair of shorts, litre of petrol, teacher's chair, etc. Results should be compared and discussed to pick out prices that are unreasonable.</p> <p>Students should be required to estimate values independently for a list containing dimension, mass, capacity, distance, etc. should be compared to pick out reasonable and unreasonable figures, e.g. capacity of a bucket, dimensions of a desk, mass of a book, height of a person, distance of local market, etc.</p>	<p>Superficial rules should be avoided.</p> <p>The laws should be discussed covered e.g. <math>(+6) + (-6) = 0</math> or <math>(-6) - (-6) = 0</math></p> <p>Bring out that when discussing prices the sizes quantity, quality, etc. should be taken into account.</p>

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS																		
	<p>6. Students will be able to determine approximate result of a given calculation.</p>	<p>Obtaining approximate values for calculations involving the four basic arithmetical processes. Rounding numbers to the nearest 1, 10, 100, 1000 as appropriate.</p>	<p>Discuss the main purpose of this work, i.e. to have a rough idea of an answer to a calculation before doing the actual calculation, and discuss the uses of this rough answer. Work a wide variety of such approximate calculations orally in class, e.g.</p> <table border="0" style="width: 100%;"> <tr> <td style="text-align: center;"><u>Actual</u></td> <td style="text-align: center;"><u>Approximation</u></td> </tr> <tr> <td>Calculation</td> <td>a little less</td> </tr> <tr> <td>18 + 19</td> <td>than 20 + 20 = 40</td> </tr> <tr> <td>75 - 39</td> <td>a little more than</td> </tr> <tr> <td>703 ÷ 21</td> <td>75 - 40 = 35</td> </tr> <tr> <td>63 x 47</td> <td>Approx. 700 ÷ 20</td> </tr> <tr> <td></td> <td>= 35</td> </tr> <tr> <td></td> <td>approx. 60 x 50</td> </tr> <tr> <td></td> <td>= 3000</td> </tr> </table>	<u>Actual</u>	<u>Approximation</u>	Calculation	a little less	18 + 19	than 20 + 20 = 40	75 - 39	a little more than	703 ÷ 21	75 - 40 = 35	63 x 47	Approx. 700 ÷ 20		= 35		approx. 60 x 50		= 3000	<p>Bring out the value of this work to the students, pointing out that most calculating errors could be corrected by the students themselves if they first determined the approximate answer. Note also that errors in decimals arise mainly from wrong placing of the decimal point so this should be adequately covered.</p>
<u>Actual</u>	<u>Approximation</u>																					
Calculation	a little less																					
18 + 19	than 20 + 20 = 40																					
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	= 3000																					

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>7. Students will have increased their competence in the number work covered during the year.</p>	<p>Exercises covering all number work covered during the year.</p>	<p><math>\frac{1}{12}</math> between <math>\frac{1}{10}</math> and <math>\frac{1}{100}</math>  i.e. one zero after the decimal point.</p> <p><math>\frac{1}{2} + \frac{2}{3} &gt; \frac{1}{2} + \frac{1}{2}</math> but <math>&lt; \frac{1}{2} + 1</math>,  i.e. between 1 and <math>1\frac{1}{2}</math>.</p> <p><math>17.32 \times 1.07</math> approx. <math>17 \times 1 = 17</math></p> <p>Students should work plenty of examples themselves, working out the rough calculation before the accurate calculation. The above examples are not exhaustive.</p> <p>Students should be given a wide variety of exercises. Individual weakness should be identified and remedial work given. Initially exercises on specific aspects should be given but after this a wide variety of practical number problems should be given, where the student has to identify the process involved.</p>	<p>A high competence in number work and its application to everyday problems is of prime importance. It is recommended that 2 weeks be set aside at the end of the year for consolidating this part of the syllabus.</p>

TOPICS	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
<p>B ALGEBRAIC PROCESSES</p>	<p>1. Students will be able to use symbols in simple mathematical statements.</p> <p>2. Students will be able to</p> <ul style="list-style-type: none"> <li>(i) perform basic operations on terms involving symbols.</li> <li>(ii) simplify algebraic expressions.</li> </ul>	<p>Open sentences. Use of letters to represent numbers.</p> <p>Basic operations applied to terms which involve symbols.</p> <p>Collecting terms involving the same symbol and collecting numbers. Use of brackets. Order of operations.</p>	<p>Consider sentences of the form <math>2 + \square = 5</math>, the role of <math>\square</math> and the use of a letter to replace <math>\square</math>. Consider the meanings of such expressions as <math>t + 3</math>, <math>m - 2</math>, <math>2s</math>, <math>2n + 6</math>. Refer to word problems, especially those related to marketing e.g. if 1 packet of sugar costs 40 kobo, how much would 20 packets of the same type cost? How much would <math>t</math> packets of the same type cost?</p> <p>Exercises should include operations such as <math>5m + 2m</math>, <math>6t - 3t</math>, <math>4 \times 2s</math>, <math>4f - f</math>.</p> <p>Plenty of exercises emphasising the use of the proper order of operations – collection of like terms, removal and use of brackets.</p> <p>Exercises of word problems covering skills required for this objective e.g. If Uche who has 5 oranges has 2 more than John, how many oranges has John?</p>	<p>Bring out the fact that symbols enable us to express situations and ideas concisely. Emphasise the importance of defining precisely what the symbol represents.</p>

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TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>3. Students will be able to translate word sentences into mathematical statements.</p>	<p>Simple equations in one variable.</p>	<p>Substitute different values for unknown in linear sentences of the form <math>g + 2 = 5</math>. Decide what value makes the sentence true. It may be expressed in words to find the correct value e.g. to what number can 1 add 2 and obtain a result of 5?</p>	
	<p>4. Students will understand the meaning of equality with reference to simple equations.</p>	<p>Use of equality sign in sentences. Substitution of values to show whether statements are true or false.</p>	<p>Illustrate the meaning of equality by using the idea of a simple balance. By adding or subtracting quantities to each side or by dividing or multiplying each side by a common factor (excluding zero), bring out the meaning of the equality sign. At each point check for true and false sentences. Students should work a large number of simple examples.</p>	<p>Avoid the use of the expression "cancel out".</p>
	<p>5. Students will be able to solve simple equations.</p>	<p>Solution of equations of the form <math>4t + 3 = 15</math>, where there is just one unknown.</p>		

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
C GEOMETRY AND MENSURATION	<p>1. Students will be able to identify some common 3 dimensional figures.</p> <p>2. Students will be able to</p> <ul style="list-style-type: none"> <li>(i) draw shapes</li> <li>(ii) identify properties of plane figures.</li> </ul>	<p>Basic properties of cube, cuboid, pyramid, cylinder, sphere, cone and triangular prism, e.g. faces, vertices, edges.</p> <p>Properties of:—</p> <ul style="list-style-type: none"> <li>(i) Rectangle — opposite sides equal and parallel; all angles are right — angles; diagonals are equal and bisect each other; two lines of symmetry in its plane.</li> <li>(ii) Square — a special rectangle in which all sides are equal; diagonals are perpendicular and bisect the angle at each vertex; four lines of symmetry.</li> </ul>	<p>In the course of discovering the properties of the figures, students should collect models of these figures from everyday life. They should also identify related figures in their surroundings that they cannot bring to the classroom. They should make models of the figures in cardboard, straw, wood, plasticine, local clay, etc. as local conditions allow. Attention of the students should also be called to local buildings which consist of a number of different shapes joined together.</p> <p>Relate the shapes to the solids, and draw them. Students should be led to discover the properties by examining and measuring the shapes in everyday life and from their drawings. Symmetric properties should be discovered from cut outs of shapes.</p>	<p>Full use should be made of empty cartons and containers, oddments of wood from local carpenters, local materials for making bricks and pots, etc.</p> <p>Students should not be told the properties and then be asked to verify them. They must discover the properties for themselves. Students should be encouraged to draw around the objects to obtain drawings of faces.</p>

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>3. Students will be able to determine the perimeter of given plane figures.</p>	<p>(iii) <u>Isoceles triangle</u> — two equal sides, two equal base angles; one line of symmetry which bisects the base and the vertex angle, and is perpendicular to the base.</p> <p>(iv) <u>Equilateral triangle</u> — is a special isosceles triangle in which all sides and angles are equal; three lines of symmetry in the plane and these lines are concurrent.</p> <p>(v) <u>Circles</u> — all diameters are equal; every diameter is a line of symmetry; symmetrical about the centre.</p> <p>Perimeters of irregular and regular polygons, squares, rectangles, triangles, trapezia, parallelograms and circles.</p>	<p>Use string to measure round the boundaries of regular and irregular shapes. Develop the formulae for the perimeter of a square, a rectangle and a circle. Activity should involve the use of the units cm and m.</p>	



TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>4. Students will be able to determine the area of given plane figures.</p>	<p>Areas of irregular and regular shapes, including squares, rectangles, triangles, parallelograms, trapezia and circles.</p>	<p>Obtain approximate value for plane shapes by counting the squares of graph paper, geoboards etc. Develop formulae for areas of rectangles, parallelograms, rightangled triangles and circles. Use cutting and fitting method for parallelograms and circle. Both <math>cm^2</math> and <math>m^2</math> should be taught as units of area.</p>	<p>In teaching this, bring out that there is no direct relationship between perimeter and area, e.g. shapes with the same perimeters do not have the same area.</p>
	<p>5. Students will be able to determine the volume of some common 3 -- dimensional figures.</p>	<p>Volume of cubes, cuboids right--triangular prism,</p>	<p>Fill hollow cubes and cuboid with unit cubes. Develop formulae for finding the volume of cuboids. Proceed to show that the volume of a right--triangular prism is half of the volume of its related cuboid.</p>	<p>Obtaining unit cubes may present some problems but some possibilities are: sugar cubes, cubes made from local clay, wood cubes by a local carpenter or boys in a woodwork class.</p>
	<p>6. Students will be able to construct parallel and perpendicular lines.</p>	<p>Constructing parallel and perpendicular lines.</p>	<p>Parallel and perpendicular lines should be constructed using ruler and set -- square only.</p>	
	<p>7. Students will be able to use a protractor to measure angles.</p>	<p>Measuring angles. Definitions of and identification of adjacent, alternate, corresponding and vertically opposite angles.</p>	<p>Use of a protractor to measure angles. Define adjacent, alternate and corresponding angles and require the students to identify them in different diagrams.</p>	

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>8. Students will be able to identify adjacent, alternate, corresponding and vertically opposite angles.</p> <p>9. Students will be able to construct triangles.</p>	<p>Angle, sum of a triangle. Angles on a straight line. Angles at a point. Property of vertically opposite angles. Properties of alternate and corresponding angles with respect to parallel lines.</p> <p>Construction of triangles.</p>	<p>Lead the students to discover through drawing and measurement the properties of angles on a straight, angles of triangle and special angles with respect to parallel lines. Properties can also be discovered by cutting out.</p> <p>Construct triangles using ruler, set-square, protractor and a pair of compasses.</p>	<p>It is important that the students are allowed to discover these special properties for themselves</p>
D EVERYDAY STATISTICS	<p>1. Students will be able to recognise the usefulness of statistics in everyday life.</p>	<p>Discussion on purposes statistics can serve. Need for collecting data for prediction purposes.</p>	<p>Introduce realistic problems where decisions depend on data, e.g.</p> <ol style="list-style-type: none"> <li>1. priority in road improvement depends on data of traffic density.</li> <li>2. the ordering of exercise books for a school depends on data of how much has been used in the previous year.</li> <li>3. priority in house building, school building, electricity supply, water supply etc. depends on data on population movement.</li> </ol>	<p>This introduction should be brief. The collection of data is not required at this stage.</p>

TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
	<p>2. Students will be able to collect data</p> <p>3. Students will be able to present data in different ways.</p>	<p>need for collecting data for analysis purposes</p> <p>Collection of data</p> <p>Numerical presentation in any order.</p> <p>Ordered presentation of data in lists or tables.</p>	<p>Discussion on general situations where analysis of data is useful, e.g.</p> <ol style="list-style-type: none"> <li>analysis of data from the school clinic to determine the most common ailments.</li> <li>traffic census on near-by road to determine the busiest time of day.</li> </ol> <p>Collect data from the class, e.g. the month each student was born or the first letter of each student's surname</p> <p>Record the information without any ordering. Discuss what information can be gained.</p> <p>Record the same information as above in an ordered form in a list/table. Check what new information can readily be gained from the new presentation.</p>	<p>Other sources of data:-- ages, height, marks etc.</p> <p>Collection of data should be done with a purpose in view.</p> <p>In treating the content under this objective, the teacher should seek to bring out the fact that with ordering and illustration more information can be gained than from random representation</p>

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TOPIC	OBJECTIVES	CONTENT	ACTIVITIES/MATERIALS	REMARKS
		<p>Pictorial presentation of data using pictogram, bar-chart, or line — graph.</p>	<p>Next present the above information pictorially and discuss what new information is readily gained.</p>	<p>All tables and pictorial presentations should be preserved for future use.</p>
	<p>4. Students will be able to present sets of data in the most appropriate form.</p>	<p>Frequency tables, pictograms, bar-charts, and pie-charts.</p>	<p>Invite students to suggest different situations they can investigate statistically, which are relevant to their environment and from which they can derive useful information.</p>	<p>Students can work in groups so as to cover a greater variety and the results can then be studied by the whole class.</p>
	<p>5. Students will be able to determine the mode, median and mean of a set of ungrouped data.</p>	<p>Identification of mode and median in a set of data.</p> <p>Calculation of mean.</p>	<p>Identify the mode and median for all sets of data previously obtained.</p> <p>Calculate the means of these sets of data also. Discuss which of the central measures i.e. mode, median, mean, is most useful in each presentation.</p>	<p>Note that this is a revision and consolidation of work done in the Primary School.</p>

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>A. NUMBER &amp; NUMERATION</p>	<ol style="list-style-type: none"> <li>Students will be able to conceptualise large numbers</li> <li>Students will be able to identify primes, factors, multiples and perfect squares.</li> <li>Students will be able to express a fraction as a ratio, decimal or percentage.</li> </ol>	<p>Large numbers — one million and above. Large numbers in standard form.</p> <p>Primes (not exceeding 200) factors. Perfect squares Common multiples and factors Square roots by factor method. Rules of divisibility.</p> <p>Fractions, ratios, decimals (terminating and recurring) and percentages.</p>	<p>Represent large numbers practically and in visual terms, e.g. 1 metre<sup>3</sup> = 1 million cm<sup>3</sup>; number of small squares in a block of graph paper. Estimation of the number of pages in a school library; the number of seconds in the year.</p> <p>Finding primes by using the sieve of Eratosthenes. Finding factors of a number by trying 1,2,3, in order; factors of 18 are 1,2,3,6, 9,18. Also <math>18 = 2 \times 3^2</math>. Use of number patterns. Use of graph paper for number patterns. Brief treatment of L.C.M. and H.C.F.</p> <p>Express ratios as decimal fractions including simple cases of recurrence: e.g. <math>\frac{1}{5} = 0.2</math>, <math>\frac{1}{3} = 0.33 = 0.3</math>, <math>\frac{1}{9} = 0.1</math>, <math>\frac{2}{3} = 0.6</math></p> <p>Conversion between fractions, decimals and percentages.</p>	<p>The emphasis should be on the intelligent use of range estimation. Note: (i) 1 billion = <math>10^9</math> or a thousand million; (ii) notation such as 0.6 million should be treated.</p>

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TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>4. Students will be able to use fraction, ratio, decimals; percentages and proportion in everyday practical problems.</p>	<p>Household arithmetic including budgeting, savings rent, taxes, instalmental buying, etc. Commercial arithmetic including profit and loss, interest discount, commission, etc. Small decimal fractions, Standard form for numbers less than one.</p>	<p>Extension of decimal places beyond 2. Enquiry into profit and loss in trading. Applications to commerce generally. Rate of interest charged on short term loans e.g. ₦5 borrowed, ₦6 due a week later. The thickness of a page by measuring 100 pages.</p>	<p>Mention cheques, money orders, postal orders, etc.</p>
	<p>5. Students will be able to approximate numbers to an appropriate degree of accuracy.</p>	<p>Place value. Approximation. Problems using the basic operations involving money, population, exports, imports.</p>	<p>Revise place value. Discuss the need for approximation and reasons for degree of approximation. Consider many practical examples, e.g. population of a large town to the nearest thousand, the population of a small village to the nearest ten, the height of a person to the nearest cm. Students should be asked to produce many different examples.</p>	<p>Caution should be exercised not to encourage false notion of accuracy, e.g. 1.3256cm. Mention should be made of equipment for measuring to a greater degree of accuracy when circumstances demand it. Particular reference should be made to equipment available in the school science lab. or to any being used by surveyors in the vicinity. If possible, the surveyor could be invited to the class to give a demonstration.</p>

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>6. Students will be able to</p> <ul style="list-style-type: none"> <li>(i) construct</li> <li>and (ii) use</li> </ul> <p>ready reckoners</p>	<p>Ready—reckoners — their construction and use. Square and square root tables.</p>	<p>Reading and making ready—reckoners and conversion tables for a variety of useful purposes such as cost of articles, simple interest tables, square and square root tables. Interpretation and construction of conversion graphs applied to rates of exchange, cost, etc.</p>	<p>It should be emphasised that ready—reckoners are universally used in commercial life. Bring out that the construction of ready—reckoner is based on important mathematical concepts.</p>
	<p>7. Students will be able to interpret tables and schedules.</p>	<p>Various tables, charts, records and schedules.</p>	<p>Refer to various time tables relevant to the students' environment e.g. railway if near a railway station, airways if near an airport, school time table, sports competition or tournament. Consider also other tables such as duty schedules, library records, stock records, distance charts etc.</p>	<p>In discussing the tables and schedules invite the students to comment on their usefulness.</p>
	<p>8. Students will be able to</p> <ul style="list-style-type: none"> <li>(i) multiply</li> <li>and (ii) divide</li> </ul> <p>directed numbers.</p>	<p>Multiplication and division of directed numbers</p>	<p>Give illustrations on the number line or with real life situations or with patterns of numbers to show the results of <math>(+2) \times (+3)</math>, <math>(+2) \times (-3)</math>, <math>(-2) \times (+3)</math>, <math>(-2) \times (-3)</math> etc. Refer to algebraic expansions using distributive properties.</p>	<p>The teacher is advised to use pictures to develop the result for multiplying two negative numbers or one positive and one negative number.</p>
	<p>9. Students will be able to find the multiplicative inverse and identity.</p>	<p>Multiplicative inverse and identity.</p>	<p>Use the inverses of the processes of multiplication and division.</p>	<p>Note that multiplicative inverse is the same as reciprocal.</p>

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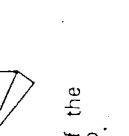
TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS	TOPIC
B ALGEBRAIC PROCESSES	1. Students will be able to expand algebraic expressions.  2. Students will be able to factorise simple algebraic expressions of not more than two terms.  3. Students will be able to simplify algebraic expressions involving fractions.	Expansion of algebraic expressions.  Factorising.  Basic operations applied to algebraic fractions with monomial denominators.	Exercises in the use of the distributive property e.g. $a(b+c) = ab + ac$ , $(b+c)a = ba + ca$ , $(a+b)(c+d) = ac+bc+ad+bd$ .  Exercises on factorisation, e.g. $ax + ay = a(x + y)$ $bc + dc = (b + d)c$ $abc + abd = ab(c + d)$ .  Application of expansion and factorisation of algebraic terms to the simplification of expressions such as $\frac{1}{3a} + \frac{1}{a} = \frac{4}{3a}$  $\frac{1}{a} + \frac{1}{b} = \frac{a + b}{ab}$	The teacher should emphasize expansion and factorisation from both the left and the right.	



RKS	TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>ould nsion and m both : right</p>		<p>4. Students will be able to solve further problems on simple equations.</p> <p>5. Students will be able to identify linear inequalities.</p> <p>6. Students will be able to solve linear inequalities in one variable.</p>	<p>Harder exercises on simple equations</p> <p>Word problems involving simple algebraic fractions.</p> <p>Linear inequalities in one variable.</p> <p>Solution of linear inequalities in 1 variable.</p>	<p>More difficult exercises on simple equations including equations involving fractions with monomial denominators.</p> <p>Word problems should be related to everyday life.</p> <p>Introduce linear inequalities through numerical examples. Examples involving inequalities, e.g. <math>Ax &lt; B</math>, where A and B are fixed numbers and X is a variable which can take any real number value. Also examples like <math>Cx &gt; D</math> which may be interpreted to mean Cx is not less than D. Use the number line.</p> <p>Illustrate the solution of inequalities on the number line. Find the range of values of X for which an inequality is true, e.g. if <math>3X &gt; 10</math>, where X is an integer, then X can be 4,5,6 ... Exercises involving inequalities of the form <math>2X + 3 &gt; 7</math>, <math>3X &lt; 5X + 1</math></p>	<p>Students should be able to solve word problems involving measurements, etc.</p> <p>Introduce the concept of inequality through practical examples, e.g. given a string of length 25 cm, find (a) the radius of a circle (b) the length of a side of a square whose circumference or perimeter is less than 25cm.</p> <p>The teacher should make sure that pupils understand that multiplication of an inequality by a negative number changes the sense of the inequality.</p>

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS	TOP
	<p>7. Students will be able to plot points in the rectangular cartesian plane.</p>	<p>Coordinate plane—axes, ordered pairs.</p>	<p>Introduce idea of rectangular axes, use of scale on the axes and choice of scale for a particular problem. Introduce the idea of ordered pairs in which (a,b) is different from (b,a) where <math>a \neq b</math>. Given ordered pairs, locate them in the coordinate plane.</p>	<p>Students should go through the experience themselves using graph books. The teacher should improvise a graph cloth or graph board for demonstration purposes.</p>	<p>C. Geom Mens</p>
	<p>8. Students will be able to:</p> <ul style="list-style-type: none"> <li>(i) compile tables of values,</li> <li>(ii) draw graphs from tables</li> </ul> <p>and (iii) obtain information from graphs</p>	<p>Linear equations in two variables. Compilation of tables. Linear graphs from practical situations.</p>	<p>Compile table of values, e.g. price of one type of item as the number of items increases, leading to the drawing of graphs of the type <math>y=ax</math>. Use simple distance — time graphs to illustrate linear graphs, e.g. walking, motoring, etc. Consider also cost situations leading to graphs of the form <math>y=ax+b</math>, i.e. where there is a basic cost added to the cost per item. Draw graphs of both types.</p>		
			<p>Conversion graphs, Distance—time graph, velocity—time graph, etc.</p>	<p>Use drawn graphs to obtain information. Rate of change.</p>	

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
C. Geometry & Mensuration	1. Students will be able to: <ul style="list-style-type: none"> <li>(i) identify properties of more plane figures.</li> <li>(ii) recognise symmetric properties of plane figures and patterns</li> </ul>	Parallelograms, rhombus, kite and circle bringing out the following properties:— <ul style="list-style-type: none"> <li>(a) <u>Parallelogram</u> <ul style="list-style-type: none"> <li>(i) Opposite sides are equal and parallel.</li> <li>(ii) Diagonals bisect each other.</li> <li>(iii) Opposite angles are equal.</li> <li>(iv) No line of symmetry.</li> </ul> </li> <li>(b) <u>Rhombus</u> <ul style="list-style-type: none"> <li>(i) All sides are equal.</li> <li>(ii) Opposite angles are equal.</li> <li>(iii) Diagonals bisect at right angles.</li> <li>(iv) Diagonals are lines of symmetry.</li> </ul> </li> <li>(c) <u>Kite</u> <ul style="list-style-type: none"> <li>One line of symmetry.</li> </ul> </li> </ul>	Discovering the properties listed under content by, for example, cutting shapes out of paper and folding to obtain lines of symmetry and other properties.	The teacher should lead pupils to discover relationships such as <ul style="list-style-type: none"> <li>(i) a square is a parallelogram but a parallelogram may not be a square.</li> <li>(ii) rectangle, rhombus are special parallelograms.</li> <li>(iii) rhombus and square are kites but there are kites which are not parallelograms.</li> </ul> In general, the teacher should make pupils construct examples where a geometrical statement is true while the converse is not necessarily true or false, e.g. in example (ii) above.

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	2. Students will be able to find the sum of the interior angles of a convex polygon.	Angle sum of a convex polygon.	<p>Polygon — Divide an n-sided polygon into <math>n-2</math> triangles or into <math>n</math> triangles.</p>  <p>In the first case, the sum of the interior angles is <math>(n-2) \times 180^\circ</math>.</p> <p>In the second case, it is <math>(n \times 180^\circ) - 360^\circ</math>. The method used should be illustrated by several examples before a generalization is arrived at.</p> <p>Practical drawing of shapes to produce textile designs.</p>	
	3. Students will be able to form patterns using plane shapes.	Combination of plane shapes to produce a design.	<p>Make freehand drawing of objects. Consider factors determining choice of scale and make accurate drawings. Use of scale drawings for maps, plans, etc.</p>	
	4. Students will be able to draw plane objects to scale.	Scale drawing.	<p>Exercises in indirect measurements using ratio and proportions e.g. heights, distances using shadows.</p>	
	5. Students will be able to determine actual dimensions of plane objects from a scale drawing.	Calculation from scale drawings using ratio and proportion.		

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>6. Students will be able to</p> <ul style="list-style-type: none"> <li>(i) distinguish between angles of elevation and angles of depression.</li> <li>(ii) measure angles of elevation and depression.</li> <li>(iii) use angles of elevation and depression in calculating measurements.</li> </ul>	<p>Angles of elevations and depressions.</p>	<p>Give examples of angles of elevation, e.g. angle of viewing the top of a palm tree, etc. Also give examples of angles of depression e.g. viewing a person from a high building.</p> <p>Construct and use a large protractor for measuring angles of elevation or depression in the school neighbourhood.</p> <p>Use angles of elevation and depression in scale drawings and also to find the heights of trees and buildings, etc.</p>	
	<p>7. Students will be able to identify the bearing of an object with reference to a given point.</p>	<p>Bearings.</p>	<p>Give bearings in the form <math>035^{\circ}</math>, <math>210^{\circ}</math>, etc.</p>	<p>Compasses should be used if available or a big protractor constructed with a pointer.</p>
	<p>8. Students will be able to use scale drawings to</p> <ul style="list-style-type: none"> <li>(i) locate the positions of objects</li> <li>and (ii) find distances.</li> </ul>	<p>Scale drawings of the position of objects and buildings etc.</p>	<p>Give examples of bearings, e.g. Give the bearing of one object on the school compound from another. Let the pupils draw the diagram of the bearings.</p>	

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>9. Students will be able to use Pythagoras's rule on rightangled triangles.</p> <p>10. Students will be able to calculate</p> <ul style="list-style-type: none"> <li>(i) the curved surface area</li> <li>(ii) the total surface area</li> <li>(iii) the volume of cylinders and cones.</li> </ul>	<p>Pythagoras's Rule.</p> <p>Surface area of cylinders and cones.</p>	<p>Use the idea of scale drawing to find distances involving bearings, e.g. the bearings of a town A from a town B is <math>035^\circ</math>. If A is 158km from how far North of A is B?</p> <p>Lead students to discover Pythagoras's rule. Count squares to show the rule in a few cases. Draw attention to Pythagorean triples like 3,4,5; 5,12,13; etc. Apply the rule to calculate lengths.</p> <p>Make solids from nets. Obtain the surface area of solids by calculating areas of nets.</p> <p>Discuss units of area. Develop the formula for the total surface area of cylinder: <math>(2Tr + 2Tr^2)</math> and cone <math>(Tr + Tr^2)</math></p>	<p>e.g. Use a square of side <math>a + b</math>, or any numbers you choose. Show, using the diagram below, that <math>a^2 + b^2 = c^2</math></p>

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>11. Students will be able to estimate numbers, dimensions, capacity, quantities, etc. for a given situation.</p>	<p>Volume of cylinder and cone.</p> <p>Rough estimates of everyday common sizes, quantities, capacity, etc.</p>	<p>Derive the formula for the volume of a cylinder. Make cardboard models of cone and cylinder of the same height and the same circular base. Compare volumes of content of cone and cylinder to discover the formula for the volume of a cone.</p> <p>Practical examples within the experience of the students, e.g. the number of beds which can be accommodated in a dormitory, number of cups of water to fill a bucket, to estimate required number of buckets for a dining hall, the number of servings from a 100kg bag of rice, the number of chairs and desks a room can accommodate for an examination. Discuss the consequences of unreliable estimates in some cases. Discuss also the variation in some cases, e.g. the number of pages different students would require in writing an essay of 1000 words, or the number of pages different students would take to cross a hall.</p>	<p>The repeated need for reliable estimates in the life of the individual and of the government of the country should be emphasised.</p>

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TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
D EVERYDAY STATISTICS	1. Students will be able to investigate examples which illustrate the idea of probability.	Discussion on occurrence of chance in everyday life. Practically determining the probability of certain events.	Invite students to give examples of chance in everyday life, e.g. the probability of rain falling on a particular day in a particular season. Investigate with the students the probability of having male/female children in their families by asking the students to list the offspring of their mother in order by male, female, then the offspring of the mother's brothers and sisters, then the offspring of the father and of his brothers and sisters so that each student builds a picture of the number of male and female in their family and so can estimate the probability of their own offspring being predominantly male or female. Investigate practically also the number of times a specified number occurs in a certain number of throws of the dice and so determine the proportion; apply it to games like ludo where a player may require a specific number.	Teachers should consider any local indigenous chance operation e.g. throwing kola-nuts to determine whether it will rain, etc.

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YEAR III

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>under any ice ng kola hether</p> <p>A NUMBER &amp; NUMERATION</p>	<p>1. Students will be able to apply binary numbers as a two way classification system using punch cards.</p> <p>2. Students will have gained competence in applying the basic operations to common and decimal fractions in word problems.</p>	<p>Binary counting system. The punched card (=yes, 0=no; intersection presented as "yes, yes". Complement presented as "no".</p> <p>The interpretation of word problems into numerical expressions and equations using brackets and fractions.</p>	<p>Producing and using simple punch cards. Collecting data on simply made punch cards (3 or 4 holes only). Library reading and other activities requiring the use of "punch tape" (TELEX). Students could code their names in binary and write it on strips of paper (to serve as tapes).</p> <p>Translation between numbers and words e.g. <math>(2+7)-3</math> is the same as <math>\frac{9}{9}</math></p> <p>'one ninth of the difference between the sum of 2 and 7 and the number 3'; 'from the product of 10 and 7 subtract 24 and then divide the result by 3' is the same as <math>\frac{(10 \times 7) - 24}{3}</math></p>	<p>Students are not required to make their own punch cards.</p>

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>3. Students will be able to solve problems involving inverse proportion.</p>	<p>The concept of inverse proportion. Study of applications such as speeds, productivity, consumption, and reciprocal. Compound Interest.</p>	<p>Preparation of speed, time and distance tables. Use of ready reckoners. Other practical problems on inverse proportion. Preparation and use of reciprocal tables. Compound interest.</p>	<p>Compound Interest should be considered on yearly basis without the use of formula.</p>
	<p>4. Students will be able to (i) identify non-rational numbers, and (ii) determine the approximate value of some non-rational numbers.</p>	<p>Non-rational numbers</p>	<p>Trial and error approach to square-roots. Experiments with circles to obtain, by graphs, the constant <math>\frac{C}{D}</math>, i.e. <math>\pi</math>  Some historical approaches e.g. Archimedes approximation of <math>\pi</math> Applying Pythagoras Theorem to the diagonals of a unit square.</p>	
	<p>5. Students will be able to use approximation in measurement.</p>	<p>Decimal places and significant figures. Problems in mensuration involving volume, area of land, distances, consumer arithmetic, games and athletics timing, etc.</p>	<p>Interpretation of data such as population. Rounding off in multiplication and addition to a reasonable degree of accuracy. Calculation using standard form e.g. <math>(1.36 \times 10^{-5}) \times (2.43 \times 10^6)</math></p>	<p>This should be related to the pupil's work in Science and Geography. Relate calculation using standard form to the use of a calculating machine.</p>

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>B ALGEBRAIC PROCESSES</p>	<p>1. Students will be able to factorise algebraic expressions.</p> <p>2. Students will be able to solve simple equations involving fractions.</p>	<p>Factorisation of expressions of the form <math>a^2 - b^2</math>, <math>3a - cb - 3b + ac</math>, <math>a^2 + 2ab + b^2</math>.</p> <p>Solution of equations involving fractions, i.e.</p> $\frac{1}{a + 2} = \frac{3}{a - 3}$	<p>Working problems on factorisation with numerical examples.</p> <p>Solve a variety of simple equations involving fractions with practical applications to word problems.</p>	<p>Note its use for rapid calculations.</p>
	<p>3. Students will be able to solve simultaneous linear equations in two variables</p> <p>(i) graphically and (ii) by calculation</p>	<p>Graphical treatment of simultaneous linear equations.</p>	<p>Construct table of values and use table to draw two linear graphs using the same axes.</p>	<p>The intersection of the two lines is the solution of the two linear equations.</p> <p>When the two lines are parallel, there is no simultaneous solution.</p>
	<p>4. Students will be able to solve problems involving variation.</p>	<p>Simultaneous linear equations of the form <math>x + 3y = 5</math> <math>2x + y = 7</math></p>	<p>Solution of simultaneous equations by standard methods.</p> <p>Application to word problems.</p>	<p>Encourage checking of accuracy of answers by substitution.</p>

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TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	5. Students will be able to change the subject of a formula.	Direct variation: $y=kx$ Inverse variation: $y=K/x$ Partial variation: $y=kx + c$ Joint variation: $y=\frac{kc}{x}$  Change of subject of formulae.	Solve a variety of problems like, e.g. (i) If 1 packet of sugar costs x kobo what will be the cost of 20 packets? (ii) Speed, time problems.  Exercises involving change of formula, e.g. if $2x = y=d$ , express x in terms of y and d.	The students should see these as examples of relationship between two variables.
C. Geometry & Mensuration	1. Students will be able to draw views and plans of common solids  2. Students will be able to identify similar figures.	Views, plans and sketches of cube, cone, cuboid, cylinder, sphere.  Similar shapes: triangles, rectangles, squares, cubes and cuboids. Enlargements and scale factor.	Use models of solids to identify and draw their plans and views. Free hand sketches of objects from different angles should also be included.  Compare angles and sides of similar figures by measurement, sliding rotation or tracing. Identify corresponding sides and angles. Examples like the pin-hole camera could serve as illustration.	Note that: 1. in similar figures (i) corresponding angles are equal, and (ii) ratio of corresponding sides is a constant. 2. all squares are similar and all cubes are similar.

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>3. Students will be able to compare lengths, areas and volumes of similar figures.</p>	<p>Use of the scale factor to calculate lengths, areas and volumes in practical problems.</p>	<p>Find the ratio of corresponding sides, areas and volumes as appropriate. Practical examples leading to calculation of lengths, areas and volumes of similar objects.</p>	
	<p>4. Students will be able to determine the sine, cosine and tangent of an acute angle.</p>	<p>The sine, cosine and tangent of an acute angle. Use of similar right-angled triangles.</p>	<p>Determine the values of sine, cosine and tangent of acute angles from ratios of appropriate sides. Application to finding distance and lengths in practical problems.</p>	
<p>5. Students will be able to solve further problems on areas</p>		<p>Areas of triangles, parallelograms, trapezia and circles.</p>	<p>Use examples arising from physical or technical situations and other everyday problems, e.g. concentric circles figures related to metal work or wood work, road signs, roofing, tiling.</p>	<p>It should be possible to solve the problems without using logarithm tables. Note that lengths may be calculated using trigonometric ratios.</p>
<p>6. Students will be able to perform constructions using a pair of compasses and a ruler.</p>		<p>Bisection of a line segment. Bisection of an angle. Construction of angles of size <math>90^\circ</math>, <math>60^\circ</math>, <math>45^\circ</math>, <math>30^\circ</math>. Copying a given angle.</p>	<p>Bisection of line segments and angles using compasses and a straight edge. Checking accuracy of construction by measurement or paper folding. Applications to constructing triangles and related figures.</p>	

TOPIC	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>D EVERYDAY STATISTICS</p>	<p>1. Students should have consolidated their knowledge of statistical presentations and concepts.</p>	<p>Revision of earlier work and further examples Mean, median, mode and range.</p>	<p>Students should suggest and investigate further relevant situations statistically, Students should be led to deduce that:</p> <ol style="list-style-type: none"> <li>1. The arithmetic sum of the deviations from the mean is zero.</li> <li>2. The product of the mean and the number of items, is equal to the total sum of the items.</li> </ol> <p>Students should also consider distributions with the same mean and different ranges, and distributions with the same range but different means. The position of the mode relative to the extreme values should also be considered. Consider possible explanations for its position.</p>	<p>It should be possible to do all examples without using assumed mean and grouped data.</p>

APPENDIX A-2

# MATHEMATICS

CURRICULUM


FOR

SENIOR SECONDARY SCHOOLS

YEAR 4

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>A. NUMBER &amp; NUMERATION</p>	<p>Students will be able to:</p> <p>i) use the laws of indices in calculations and simplifications:</p> <p>ii) explain the relationship between indices and logarithms:</p> <p>iii) use logarithms tables in calculation.</p>	<p>Revision of standard form</p> <p>Indices as a shorthand notation.</p> <p>Laws of indices</p> <p>Meaning of <math>\alpha^0, \alpha^{-n}, \alpha^h</math></p> <p>Graphs of <math>y = 10^x</math> (<math>0 \leq x \leq 1</math>)</p> <p>Use of graph for multiplication and division.</p> <p>Base 10 logarithm tables and antilogarithm tables.</p> <p>Calculation involving multiplication, division, powers and square roots.</p>	<p>Use of indices as a standard notation, Laws of indices i.e. <math>x^a \div x^b = x^{a-b}</math>, <math>x^a \times x^b = x^{a+b}</math>, <math>x^a \div x^b = x^{a-b}</math>, <math>(x^a)^b = x^{ab}</math> should be discovered. Deduce meaning of <math>\alpha^0, \alpha^{-n}, \alpha^h</math>, e.g. by considering <math>a^n \div a^n = 1, a^0 = 1</math> etc.</p> <p><math>\alpha^p \times \alpha^q = \alpha^{p+q}</math></p> <p>Show indices and logarithms as inverse operations</p> <p><math>y = 10^x \quad x = \text{Log}_{10} y</math></p> <p>Examples to develop from simple case to a complex combination of multiplication and division of numbers, powers and square roots</p> <p>e.g. <math>\frac{67 \times (43)^2 \times \sqrt{13}}{143 \times 16}</math></p>	<p>In teaching this, the use of indices, in science, geography, economics etc. should be brought out and exercises should be related to practical use.</p> <p>Not necessary for students to draw the graph of <math>y = 10^x</math> but they should be familiar with it.</p> <p>Numbers greater than 1 only</p>

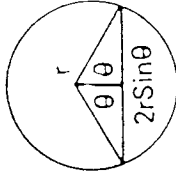


TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	iv) make mathematical statements using set notation.	Idea of set, Universal set, finite & infinite sets, empty set and sub-set. Idea and notation for union, intersection and complement of sets. Disjoint set.	Use objects in the classroom, around the school and within the home. Idea of sorting out things from a mixture to be introduced. Notation: U n. Practical examples based on students experience to be given and followed with experiences.	In teaching sets, emphasis must be on the use of sets as a tool and not as a topic for study in its own right. Sets should not therefore be used to solve problems which could be solved more quickly by other methods, except where this is done for the sake of comparison.
	Venn diagrams as disjunctive representation of sets.		To be used as an illustration, e.g. All students in a class do Mathematics. In addition some do Biology and physics, some do just one of these two subjects and others take neither of them.	The treatment of this topic should be very brief and limited to the bare essentials. Not more than three sets Interpretation in terms of union, intersection etc. to be included.
				

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>B. ALGEBRAIC PROCESSES</p>	<p>v) use venn diagrams to solve problems involving classification.</p> <p>Students will be able to: Solve quadratic equations by: i) factorisation; ii) using graphs.</p>	<p>Solution of practical problems involving classification, using venn diagrams.</p> <p>Revision of factorisation of quadratics. Solution of equations using <math>ab = 0 \implies a = 0</math> or <math>b = 0</math> Construction of quadratic equation with given roots.</p>	<p>Classification of specimens based on students' experiences in the home and school to be given Alternative methods of solving the same problems should be used and the methods compared</p> <p>Revise factorisation thoroughly, using at least 2 approaches e.g. grouping and considering the factors of <math>c</math> in the expression. <math>X^2 + bX + C</math> Lead the students to realise that if either of the factors is equal to zero, the equation is satisfied</p>	<p>Alternative method of solving the problems should be considered, particularly with the brighter student and the advantages and appropriateness of different methods considered.</p> <p>The use of <math>ab = 0 \implies a = 0</math> or <math>b = 0</math> need not lead to the use of formula.</p>

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
		<p>Drawing quadratic graphs Obtaining roots from graphs</p>	<p>e.g.:  <math>(X + 2)(X - 3) = X^2 - X - 6 = 0</math>                      if <math>X + 2 = 0</math> or <math>X - 3 = 0</math> because  <math>0 \cdot (x - 3) = 0</math> and <math>(X + 2) \cdot 0 = 0</math>,                      solving <math>X + 2 = 0</math> and <math>X - 3 = 0</math>                      therefore gives the solution of  <math>X^2 - X - 6 = 0</math></p> <p>The solution should be substituted in the original equation as a cross-check.</p> <p>Students should be led to construct table of values for a given range of the independent variables. Students should be guided to join the points by a smooth curve (freehand).</p>	<p>The graphs of some of the equations solved by calculations earlier should be drawn and the results compared.</p>

TOPICS.	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
C. MENSURATION	<p>Students will be able to determine</p> <p>i) lengths and areas related to the circle;</p>	<p>Length of arcs of circles Perimeter of sectors and segments.</p> <p>Areas of sectors and segments of a circle.</p>	<p>Draw circles. For each circle draw in various sectors and list in pairs the angle at the centre (<math>\theta</math>) and the arc <math>l</math> measured with string. For each sector compare the ratios.</p> $\frac{l}{360} \text{ and } \frac{A}{2\pi r}$ <p>Deduce the formula</p> $l = \frac{2\pi r \theta}{360}$ <p>Work various examples on perimeters</p> <p>Use trigonometric ratios when required to determine lengths of chords.</p> <p>Draw circle. Cut into a number of sectors of equal angles at the centre e.g. sectors of <math>60^\circ, 72^\circ, 90^\circ</math>. Measure the angle and compare the ratios <math>\frac{\theta}{360}</math> and <math>\frac{A}{\pi r^2}</math></p> <p>Deduce the formula <math>A = \frac{\pi r^2 \theta}{360}</math></p>	

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	ii) the surface area of the cube, cuboid, cylinder and cone.	Relation between the sector of a circle and the surface area of a cone.	Given copious examples. Use trigonometric ratio to determine the length of the chord i.e.  Cut open a cone to obtain sector of a circle. Deduce the formulae: area of curved surface is $\pi r \ell$ where $r$ is based radius and $\ell$ is slant height.	Develop surface area and volume of cube, cuboid, cylinder and cone. Develop surface area and volume of further 3-dimensional shapes including compound shapes (excluding the Sphere)

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
D. PLANE GEOMETRY	Students will be able to: i) perform further constructions using a pair of compasses and a ruler.	Revision of construction of: triangles, bisector of a line segment, bisector of an angle, angles of $30^\circ$ , $45^\circ$ , $60^\circ$ and $90^\circ$	Draw thin (geometrically acceptable) line segments. Make arcs and curves to form patterns and to facilitate the use of a protractor and pair of compasses.	Locus of points should be shown to be directly related to parallel lines, bisectors, angle bisectors etc. during the teaching of this topic
		Construction of: an angle equal to a given angle.	Construct lines perpendicular to each other, Measure the angles.	
		4-sided plane figures given certain conditions.	Construct lines parallel to given lines under various conditions, using straight edge and moving set squares.	
		locus of moving points including equidistant from 2 lines or 2 points, and constant distance from a point.	Construct an equilateral triangle and thus an angle of $60^\circ$ . Bisect it and measure. Use the basic constructions of given angles, perpendicular and parallel lines to construct triangles, parallelograms, rhombus etc. Always measure to ensure accuracy.	
			Relate locus of points to the above constructions where possible, giving practical problems as examples.	

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	<p>ii) write out formal proofs of some basic theorems in Euclidean geometry;</p> <p>iii) apply the skills of deductive reasoning in proving theorems in Euclidean geometry.</p>	<p>Deductive proofs of: an angle sum of a triangle.</p> <p>areas of triangles between angles based on the axiom that the sum of angles on a straight line is <math>180^\circ</math>.</p> <p>Riders should include: angles on parallel lines, angles in a polygon, congruent triangles, properties of parallelograms, intercept theorems.</p>	<p>Make students follow through initially a clear format of Given: Required to be proved: Construction: (Where necessary) Proof: (Statement and Reason) Distinguish between the theorems whose proofs must be reproduced faithfully and those theorems that should be recognised and used.</p> <p>Exercises and riders to help students reproduce arguments based on reasons (theorems or axioms).</p> <p>Follow gradually with riders involving angles in the plane; emphasize symmetry especially with the isosceles and equilateral triangles.</p> <p>Riders on congruence.</p> <p>Experiments with paper cut-outs on the various conditions for congruence.</p>	<p>Any attempt at rote learning of proofs shall be seriously discouraged. Emphasis should be on correct deductive reasoning in all proofs.</p>

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
			<p>Rotate and shade figures to show perfect fit or congruence.</p> <p>Riders on areas of triangles and parallelogram on same or equal bases and between same parallels.</p>	
<p>E. TRIGONOMETRY</p>	<p>Students will be able to</p> <p>i) use the tangent, sine and cosine ratios in relation to the sides of right angled triangles in practical problems;</p>	<p>Revision of sine, cosine and tangent with respect to right angled triangle.</p> <p>Trigonometric ratios of <math>30^\circ</math>, <math>45^\circ</math> and <math>60^\circ</math></p> <p>Application to simple problems.</p>	<p>Revise trig. ratios -- determine ratios for <math>30^\circ</math>, <math>45^\circ</math>, <math>60^\circ</math>, by referring to appropriate special triangles.</p> <p>Give example practical everyday examples including problems related to subjects like Physics, Geography studies by the students.</p>	



TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	ii) identify the trigonometric ratios of the special angles $30^\circ$ , $45^\circ$ and $60^\circ$ iii) relate the sine and cosine ratio to the unit circle.	Trigonometric ratios related to the unit circle. Graphs of sine and cosine for $0^\circ \leq X \leq 360^\circ$ .	Use of unit circles and graph to deduce these ratios.	Lead the students to realise that the values of the sine and cosine of angles lie between $+1$ , $-1$ . Note the symmetric properties of both the circle and the graphs.
F. STATISTICS  ii) graphs of statistics, thereby making useful inferences about the distribution.  iii) the meaning of standard deviation for a set of discrete data.	Students will be able to interpret: i) the mean, median and mode of any set of data.  ii) graphs of statistics, thereby making useful inferences about the distribution.  iii) the meaning of standard deviation for a set of discrete data.	Collection, tabulation and presentation of data. Frequency table. Rectangular graphs, pie charts, bar charts, frequency polygons line graphs.  Reading and drawing simple inferences from graphs.	Collect data from the class e.g. month in which each pupil in the class was born, number of children per family, population of towns etc. Limitation and misuse of line graphs should be brought out.  Temperature and rainfall charts, hottest day, and month with heaviest rainfall  No. of cocoa pods on a cocoa tree, scores in a test or examination.	Better understanding of median and mode than in Year 3 should be aimed at.

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
A. NUMBER & NUMERATION	<p>Students will be able to:</p> <ul style="list-style-type: none"> <li>i) use logarithms tables to perform further calculations</li> <li>ii) determine the degree of accuracy of a result in a problem;</li> <li>iii) calculate the percentage error of a result or measurement.</li> <li>iv) identify the pattern of a sequence and find any term.</li> </ul>	<p>Revision of logarithms of numbers greater than 1. Logarithm of numbers less than 1. Reciprocals.</p> <p>Revision of approximations and significant figures. Accuracy of results using logarithm tables.</p> <p>Percentage error.</p> <p>Revision of work done in year 3 on A.P. and G.P. More problems on A.P. and G.P. Determining the <math>n^{\text{th}}</math> term of a given sequence.</p>	<p>Revise earlier work on logarithms</p> <p>Comparison to be made between results obtained using logarithm tables and straight calculations.</p> <p>Students to use a meter rule to measure the length, say, of the class table and find the percentage error in each measurement.</p> <p>Exercises to include sequences other than A.P. and G.P. e.g. prime numbers, 1, 3, 7, 15, 31, 63 where each term is obtained by doubling the preceding term and adding one.</p>	<p>Characteristic of the logarithm and standard form of a number may be compared. A revision of place value may be found useful in the teaching of this topic.</p> <p>Students need not use the slide rule or pocket calculator, though with some classes comparisons of logarithms, slide rules and calculators may be possible and well worth-while.</p> <p>Brighter students may be led to consider possible acceptable and unacceptable percentage errors for particular measurements.</p> <p>Series other than A.P. and G.P. should be restricted to very simple ones. A lengthy and deep treatment of this is not expected.</p>

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>B. ALGEBRAIC PROCESSES</p>	<p>Students will be able to:</p> <p>i) solve quadratic equations by completing the square;</p> <p>ii) solve a pair of simultaneous equation where one is linear and the other is quadratic, graphically;</p>	<p>Quadratic expressions as the sum of the square of a linear expression and a constant.</p> <p>Solution of equation by completing the square.</p> <p>Reducing formula from completion of square.</p> <p>Graphical solution of a pair of equations of the form <math>= aX^2 + bX + c</math> and <math>y = mx + k</math>.</p> <p>Use of a quadratic graph to solve a related equation e.g. graphy of <math>y = X^2 + 5X + 6</math> to solve <math>X^2 + 5X + 4 = 0</math></p>	<p>Student should observe the result of the expansion of expressions like <math>(X \pm a)^2</math>.</p> <p>Given an expression of the form <math>E = X^2 \pm aX + k</math>, students should learn to find the constant term, k, which can be added to the expression so as to make the result a perfect square e.g. <math>(X^2 + 6X) + 9 = (X+3)^2</math></p> <p>After drawing the two graphs, students should be able to recognize the points of intersection as the solutions of the equations.</p>	<p>This method of solving quadratic equations should be compared with the earlier methods used and the different methods be applied to the same equation.</p>

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	iii) determine the gradient of a curve at a given point ;  iv) draw the graphs of linear inequalities in two variables.	Drawing of a tangent to a curve. Use of tangent to determine gradient.  Revise linear inequalities in one variable. Graphs of linear inequalities in two variables.	Use a set-square to draw tangents to curves at given points.  Exercises should include practical problems where there are restrictions on two variables.	Do not attempt to introduce linear programming.
C. PLANE GEOMETRY	Students will be able to prove:  i) further basic theorems in Euclidean geometry.  ii) riders on the Euclidean geometry of the circle.	Deductive proofs of: i) the angle which an arc subtends at the centre is twice the angle it subtends at the circumference ; ii) angles in the same segment are equal. iii) Riders based on the above two theorems including the following; angles subtended by chords in a circle, angles subtended by chords at the centre; perpendicular bisectors of chords; angles in alternate segments.	Students should write out the proofs of these theorems precisely, noting in particular the body of information given by the theorems. Revision of the theorems, properties etc. met so far relating to: i) angles in a plane ii) congruent triangles iii) parallelograms iv) intercepts and mid points v) pythagoras and it extension vi) Areas. Use of any of the above together with either or both of the theorems in the content to proof riders on circles and write out the proofs formally.	

OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
		<p>Let students place emphasis on dependence of the truth of any statement on theorems previously accepted. Emphasize the step by step nature of deductive proof and the if -- then relationships.</p> <p>Use the ideas of rotation, enlargement and translation in proving theorems.</p>	
<p>will be able to solve problems involving elevation, depression, bearings.</p>	<p>Revision of trigonometric ratios. Revision of angles of elevation, depression, and bearings of practical problems involving calculation of lengths and angles.</p>	<p>Basic revision exercises on the ratios. Ample practical examples using them in problems involving angles of elevations and depression, and bearings.</p>	

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
E. PROBABILITY	<p>Students will be able to</p> <ul style="list-style-type: none"> <li>i) associate the probability of an event with an exact measure by experimentation</li> <li>ii) associate the probability of an event with an exact measure by theory.</li> <li>iii) determine the probability of mutually exclusive events in the same population.</li> </ul>	<p>Probability of throwing a six with a dice, or a head when tossing a coin.</p> <p>Theoretical probability as a limiting value of experimental probability as the number of trials becomes large.</p> <p>Addition and multiplication of probability for mutually exclusive events. Interpretation of 'and' or 'or' in probability.</p>	<p>Throwing a dice or tossing a coin, Number of males and females in different families and corresponding probability of a male issue. Note tendency for majority cases to be close to 1, 2.</p> <p>Theoretical consideration of tall parents producing tall children Consider also 1 tall 1 short parent and probable offspring.</p> <p>Selection of a committee of boys and girls from a mixed class. Probability of choosing a particular route from A to C through B where there are a number of routes joining A and</p>	

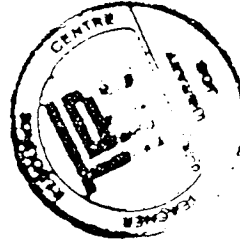
YEAR 6

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
A. NUMBER & NUMERATION	Students will be able to identify and apply the basic rules of logarithms.	<p>The rules to be deduced are</p> $\log_{10}(pq) = \log_{10}p + \log_{10}q$ $\log_{10}(p/q) = \log_{10}p - \log_{10}q$ $\log_{10} p^n = n \log_{10} p$ <p>Use of logarithm tables in problems on Compound interest, investment and annuities etc.</p>	<p>Sketches and comparison with indices to be made.</p> <p>Exercises to lead to the verification of these rules e.g.</p> $\log_{10} 20 = \log_{10} (2 \times 10)$ $= \log_{10} 2 + \log_{10} 10$ $\log_{10} 16 = \log_{10} 2^4 = 4 \log_{10} 2.$	
B. ALGEBRAIC PROCESSES	Students will be able to solve word problems involving quadratic equations.	Application of solution of linear and quadratic equations in practical problems.	Formulating problems leading to quadratic equations.	

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
C. MENSURATION	<p>Students will be able to</p> <ul style="list-style-type: none"> <li>i) deduce the surface area and volume of a sphere.</li> <li>ii) determine distances along lines of latitude and longitude.</li> </ul>	<p>The surface area and volume of a sphere.</p> <p>The earth as a sphere. Calculations of distances on the surface of the earth.</p>	<p>Use a transparent sphere to introduce the equatorial plane. Give the definition of the latitude and longitude as angles. Compare with geographical definitions and relate both sets of definitions.</p> <p>Treat very simple example. Work example involving known places and check results from good atlases.</p>	



TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
<p>D. TRIGONOMETRY</p>	<p>Students will be able to draw the graph of sine and cosine for angles of <math>0^\circ</math> to <math>360^\circ</math></p>	<p>Graphs of sine and cosine between <math>0^\circ</math> to <math>360^\circ</math></p>	<p>Revise earlier work done in year 4 and extend graphs to <math>360^\circ</math>. Consider symmetric properties etc.</p>	
<p>E. STATISTICS</p>	<p>Students will be able to</p> <ul style="list-style-type: none"> <li>i) draw histograms for sets of data.</li> <li>ii) analyse data represented in histograms.</li> </ul>	<p>Presentation of grouped data using histograms.  Interpretation of data in histograms.</p>	<p>The need to group data. Choice of a suitable number of groups.  Practical examples within the understanding of the students.</p>	

TOPICS	OBJECTIVES	CONTENTS	ACTIVITIES/MATERIALS	REMARKS
	iii) determine the mean, median and mode of grouped data.	Using cumulative frequency graph to estimate the percentiles (including median)	Examinations scores ranging say from 10 to 90 in a class of 30 pupils. The % of the class scoring below a certain mark.	Assumptions in using grouped data to estimate mean, mode and median should be emphasised.
	iv) describe a distribution using the quartile and inter-quartile ranges;	quartiles of percentiles.		
	v) determine the mean deviation and standard mean deviation for a distribution.	Calculation of mean deviation and standard mean deviation.	Revise standard deviation for discrete data. Extend this to calculations of mean deviation and standard deviation for grouped data.	It is essential that examples chosen for these calculations are meaningful to the students so that the students can appreciate the value of the calculations.

APPENDIX B

ITEM OBJECTIVES  
FOR THE  
SCHOOL MATHEMATICS CONTENTS TEST (SMCT)

## TEST ITEMS OBJECTIVES

The student teacher should be able to:

1. name and identify some common number systems.;
2. solve problems involving basic arithmetical processes;
3. demonstrate an understanding of the hierarchy of arithmetic operations as applied to fractions;
4. apply basic arithmetical processes to decimal fractions;
5. identify, add and subtract integers;
6. make a sensible estimate of a measure used in everyday life;
7. make use of estimation and approximation to check that the results of calculations are of the right order;
8. represent large numbers practically in visual items;
9. express a positive integer as a product of primes;
10. identify the set of all factors of a number;
11. identify the multiples of a given number;
12. identify a specified perfect square;
13. express a fraction as a ration;
14. convert fractions to decimals;
15. convert fractions to percentages;
16. find one number as a percentage of the other;
17. calculate using ratios in a variety of situations
18. use decimals in everyday practical problems;

19. use percentages in everyday practical problems;
20. use proportions in everyday practical problems;
21. approximate using a specified number of significant figures or decimal places;
22. interpret tables and schedules;
23. multiply and divide directed numbers;
24. recognise the multiplicative inverse (or reciprocal) of a number;
25. recall facts about identity elements;
26. add, subtract, multiply and divide binary numbers;
27. solve problems involving inverse proportions;
28. identify non-rational numbers;
29. interpret statements given in symbolic form;
30. translate word sentences into mathematical statements;
31. simplify algebraic expressions (including those involving fractions);
32. substitute values in algebraic expressions;
33. solve simple equations (including those involving fractions);
34. expand algebraic expressions;
35. factorise completely algebraic expressions;
36. identify linear inequalities;
37. solve linear inequalities;
38. plot points in the rectangular Cartesian plane;
39. complete tables of values;
40. sketch graph from tables;
41. obtain information from graphs;
42. solve simultaneous linear equations in two variables;

43. solve problems involving joint variation;
44. change subject of a formula;
45. identify some 3-dimensional figures;
46. identify properties of plane figures;
47. explain the perimeter of a polygon;
48. explain the area of a given plane figure;
49. find the volume of some common 3-dimensional figures;
50. identify adjacent, alternate, corresponding and vertically opposite angles;
51. recognise which combination of lengths cannot be used to construct a triangle;
52. find the number of sides of a convex polygon given either interior or exterior angles;
53. draw plane objects to scale;
54. determine actual dimensions of plane figures from scale drawing;
55. identify and use angles of elevation or depression in calculating distances;
56. use a scale drawing to locate the position of objects on the earth surface;
57. use a scale drawing to find distances;
58. use Pythagorean' rule on right-angled triangles;
59. calculate surface area of some regular 3 dimensional figures;
60. calculate dimensions, capacity, quantity. etc. for a given situation;
61. recognise similar triangles given certain dimensions;
62. recognise correct description of a geometrical construction;

63. determine the sine, cosine, and tangent of an acute angle;
64. determine the mode, median or mean of a set of data;
65. find the probability of obtaining any of (H,H), (H,T), (T,H), (T,T) when two coins are tossed;
66. Explain the mean, median and mode of any set of data;
67. define the term standard deviation;
68. use the laws of indices in calculations and simplifications;
69. apply the relationship between indices and logarithms in simplifications;
70. use logarithms in calculations;
71. make mathematical statements using set notations;
72. use Venn diagrams to solve problems involving classifications;
73. identify the pattern of a sequence and find any term of the sequence;
74. identify and apply basic rules of logarithms
75. solve quadratic equations by factorisation;
76. solve quadratic equations by completing the square;
77. solve a pair of simultaneous equations involving fractions;
78. put word problems in the form of mathematical statements involving simultaneous equations;
79. determine lengths of arcs and areas related to the circle;
80. recall some basic theorems in Euclidean geometry;
81. apply the skill of deductive reasoning in proving riders in Euclidean geometry;
82. determine distances along lines of latitude and longitude;
83. use the tangent, sine, and cosine ratios in relation to sides of the right-angled triangle in pictorial problems;

84. recall the trigonometric ratios of special angles e.g.  $30^\circ$ ,  $45^\circ$ ,  $60^\circ$ , and  $90^\circ$ ;
85. identify the graphs of sine and cosine for angles of  $0^\circ$  to  $360^\circ$ ;
86. identify the general equation of the lines perpendicular to a given line;
87. find the angles of a triangle by applying the idea of the angle sum of a triangle;
88. find the general equation of all lines parallel to a given straight line;
89. identify the locus of a point in two dimensions given the rule of movement;
90. find the sum of the roots of a quadratic equation;
91. convert numbers from one base to another;
92. express numbers in the standard index form using positive and negative powers of 10;
93. manipulate simple surds;
94. generalise arithmetical relations in symbols;
95. solve equations with variable indices;
96. apply the sine or the cosine rule to solve a triangle;
97. find the area of a triangle using any of the rules:

$$\text{Area} = \frac{1}{2} \text{ base} \times \text{height}$$

$$\text{Area} = \frac{1}{2}ab \sin C$$

$$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

98. present data in pie chart or bar chart or histogram;
99. recall facts about the angle sum of a polygon;
100. calculate the lengths of arcs.



APPENDIX C

THE  
SCHOOL MATHEMATICS CONTENTS  
TEST (SMCT)

### SCHOOL MATHEMATICS CONTENTS TEST ANSWER SHEET

Instructions: (1) In section A give the information requested. (2) In section B circle only ONE correct option in each case.

#### Section A

Your name (optional) \_\_\_\_\_ Sex \_\_\_\_\_ Age \_\_\_\_\_

College of Education \_\_\_\_\_ Year of training \_\_\_\_\_

Your highest qualification before entering college for training: \_\_\_\_\_

#### Section B

1. A B C D	2. A B C D	3. A B C D	4. A B C D	5. A B C D
6. A B C D	7. A B C D	8. A B C D	9. A B C D	10. A B C D
11. A B C D	12. A B C D	13. A B C D	14. A B C D	15. A B C D
16. A B C D	17. A B C D	18. A B C D	19. A B C D	20. A B C D
21. A B C D	22. A B C D	23. A B C D	24. A B C D	25. A B C D
26. A B C D	27. A B C D	28. A B C D	29. A B C D	30. A B C D
31. A B C D	32. A B C D	33. A B C D	34. A B C D	35. A B C D
36. A B C D	37. A B C D	38. A B C D	39. A B C D	40. A B C D
41. A B C D	42. A B C D	43. A B C D	44. A B C D	45. A B C D
46. A B C D	47. A B C D	48. A B C D	49. A B C D	50. A B C D
51. A B C D	52. A B C D	53. A B C D	54. A B C D	55. A B C D
56. A B C D	57. A B C D	58. A B C D	59. A B C D	60. A B C D
61. A B C D	62. A B C D	63. A B C D	64. A B C D	65. A B C D
66. A B C D	67. A B C D	68. A B C D	69. A B C D	70. A B C D
71. A B C D	72. A B C D	73. A B C D	74. A B C D	75. A B C D
76. A B C D	77. A B C D	78. A B C D	79. A B C D	80. A B C D
81. A B C D	82. A B C D	83. A B C D	84. A B C D	85. A B C D
86. A B C D	87. A B C D	88. A B C D	89. A B C D	90. A B C D
91. A B C D	92. A B C D	93. A B C D	94. A B C D	95. A B C D
96. A B C D	97. A B C D	98. A B C D	99. A B C D	100. A B C D

ANSWERS TO SMCT ITEMS<sup>1</sup>

1	A	2	C	3	B	4	D	5	B
6	B	7	D	8	B	9	B	10	B
11	A	12	A	13	C	14	B	15	D
16	C	17	D	18	B	19	C	20	D
21	D	22	B	23	D	24	D	25	A
26	C	27	B	28	D	29	B	30	D
31	A	32	C	33	C	34	B	35	C
36	C	37	A	38	C	39	B	40	A
41	B	42	A	43	B	44	D	45	A
46	A	47	B	48	C	49	B	50	C
51	A	52	B	53	B	54	C	55	B
56	C	57	A	58	D	59	B	60	D
61	B	62	B	63	B	64	D	65	B
66	D	67	B	68	A	69	A	70	A
71	A	72	A	73	D	74	B	75	C
76	A	77	C	78	C	79	B	80	C
81	B	82	B	83	D	84	C	85	A
86	C	87	A	88	D	89	C	90	C
91	C	92	B	93	A	94	A	95	D
96	B	97	D	98	D	99	D	100	B

<sup>1</sup> Shaded items were discarded and not used in the analysis (See chapters 4 and 6).

1. The system of writing numbers we now use is called the
  - A. Hindu - Arabic system
  - B. English system
  - C. Sumerian system
  - D. Egyptian system
  
2. A man drove from A to B a distance of 120km at an average of 80km/h, and then from B to A at an average speed of 48km/h where  $AB = BA$ . What was his average speed, in km/h, for the whole journey?
  - A. 64
  - B. 32
  - C. 60
  - D. 66
  
3. Simplify  $\frac{7}{8} + \frac{1}{2} \times 2\frac{1}{2} - \frac{2}{3} \times \frac{7}{8} \div 1\frac{1}{4}$ 
  - A.  $1 \frac{5}{8}$
  - B.  $1 \frac{8}{15}$
  - C.  $\frac{8}{15}$
  - D.  $\frac{5}{8}$
  
4. Evaluate  $\frac{11.5 + 5.21}{2.55 - 1.703} \times 0.001$ , correct to 4 decimal places.
  - A. 0.00393
  - B. 0.0393
  - C. 0.197
  - D. 0.0197
  
5. You are given the following list of numbers  $\sqrt{2}, 1, -2, \frac{3}{2}, 3.6, \frac{7}{22}, -1, -2$ . Find the sum of all the integers in the list.
  - A. 0
  - B. 3
  - C. 6
  - D. 9.6
  
6. The capacity of a beer bottle in Nigeria is
  - A. 10 litres
  - B. 0.72 litres
  - C. 72 litres
  - D. 7.2 litres.
  
7. What is the most sensible estimate of the answer to this problem?
$$\frac{0.25 \times 83.4}{5.7}$$
  - A. 30 or 40
  - B. 300 or 400
  - C. 0.3 or 0.4
  - D. 3 or 4

8. How many digits are there in  $(68709)^{15}$ ?

- A. 75
- B. 73
- C. 60 ✓
- D. 19

9. Express 147 as a product of primes.

- A.  $3^2 \times 7$
- B.  $3 \times 7^2$
- C.  $3 \times 49$
- D.  $1 \times 2 \times 2 \times 7$

10. Identify the set of all the factors of 12

- A.  $\{1, 2, 6, 12\}$
- B.  $\{1, 2, 3, 4, 6, 12\}$
- C.  $\{3, 4, 6, 12\}$
- D.  $\{1, 2, 3, 4, 5, 6, 12\}$

11. The elements of one of these sets are all multiples of 3, which is the set?

- A.  $\{3, 21, 51, 60\}$
- B.  $\{6, 9, 16, 25\}$
- C.  $\{3, 6, 9, 10\}$
- D.  $\{1, 2, 3\}$

12. What is the smallest perfect square divisible by 12?

- A. 36
- B. 144
- C. 216
- D. 24

13. Express  $\frac{30}{36}$  as a ratio in its smallest term

- A. 30 : 36
- B. 3 : 3.6
- C. 5 : 6
- D. 1 : 2

14. Express  $\frac{1}{8}$  as a decimal

- A. 0.8
- B. 0.125
- C. 0.0125
- D. 1.8

15. Express  $\frac{1}{125}$  as a percentage

- A.  $1/125\%$
- B.  $4\%$
- C.  $25\%$
- D.  $0.8\%$

16. Express a profit of ₦12 as a percentage return on an investment of ₦180.
- A. 0.067%
  - B. 67%
  - C. 6.7%
  - D. 0.67%
17. A restaurant owner charges for meals in proportion to the number of persons served as a group. If she collected ₦360 from a group of six people, how much would you expect to pay her for a group of eight customers?
- A. ₦400
  - B. ₦420
  - C. ₦440
  - D. ₦480
18. If ₦1 = \$1.66, convert the cost of a suit which sells for \$102 in U.S.A to Naira (₦) .
- A. ₦59.36
  - B. ₦30.71
  - C. ₦150
  - D. ₦200
19. A contractor who was given a job for ₦250,000 in January was able to start work only in December of the same year because the mobilisation fee of 10% of the total cost was paid late to him. If he now demands 5% of the balance as variation due to inflation in order to finish the job, how much <sup>more</sup> money is to be paid to him when he completes the work?
- A. ₦225,000
  - B. ₦261,250
  - C. ₦236,250
  - D. ₦11,250
20. Two farmers, Mensah and Addo, share the grazing of a field. Mensah puts in 12 cows for 18 days, and Addo puts in 15 cows for 16 days. How should Mensah and Addo share the payment of ₦8.55 rent?
- |                 |            |
|-----------------|------------|
| A. Mensah ₦4.20 | Addo ₦4.35 |
| B. Mensah ₦3.80 | Addo ₦4.75 |
| C. Mensah ₦4.52 | Addo ₦4.03 |
| D. Mensah ₦4.05 | Addo ₦4.50 |
21. Approximate 0.007138 to 3 significant figures.
- A. 0.007
  - B. 0.00713
  - C. 0.713
  - D. 0.00714

22. The postal rates for letters in Nigeria are as follows:-

Weight (g)	Charges
10g or less	45k
10g but below 50g	45k for the first 10g and 15k for each subsequent 5g or part thereof
50g but below 100g	N2.00 for 50g and 20k for each subsequent 5g or part thereof.
100g and above	N6.00
Registration (Optional)	40k

What will it cost to send a letter by registered post if it weighs 93g

- A. N6.40  
 B. N4.20  
 C. N4.00  
 D. N3.60

23. Evaluate  $\frac{(-3) \times (-2) \times 3}{-2 \times 5}$

- A. -18  
 B. 18  
 C. 1.8  
 D. -1.8

24. If "a" times a number equals 1, then that number must be

- A. -a  
 B. 1  
 C. 2a  
 D.  $\frac{1}{a}$

25. If  $a * e = a$  (where \* is a binary operation). Which one of the following statements is false?

- A.  $a * a = e$   
 B. e is an identity element if also  $e * a = a$   
 C.  $a * e = e * a$   
 D.  $a * (\text{inverse } a) = e$

26. Evaluate the following binary arithmetic  $[(10101 - 110) \times (1101 - 101) \times 11] \div 10$

- A. 1110110  
 B. 112010100  
 C. 110100100  
 D. 11211210

27. The number of spherical shot which can be made from a given volume of lead varies inversely as the cube of the diameter of the shot required. When the diameter is 0.2cm the number of shot is 270. How many shot of diameter 0.3 can be cast from the same volume of lead?

- A. 370
- B. 80
- C. 350
- D. 405

28. Which set contains irrational (non-rational) numbers only

- A.  $\{\pi, \sqrt{2}, 2, -1\}$
- B.  $\{-7, 18, \frac{25}{7}, e\}$
- C.  $\{1.41427, 1.142142, \sqrt{2}\}$
- D.  $\{\sqrt{2}, \pi, 1.4142\dots, \dots\}$

29. Choose the problem that is best represented by the following Mathematical sentence

$x 3 = 12.$

- A. Titilola had some oranges. Fatima gave her three more oranges. She now has 12 oranges. How many oranges did Titilola have to begin with?
- B. There are 12 oranges in all. There are 3 oranges in each group. How many groups of oranges are there?
- C. Sule sold 3 times as many oranges as Musa. Musa sold 12 oranges. How many oranges did Sule sell?
- D. The children bought 12 different items at the Bookshop. The Clerk put 3 items into one bag. If he put the rest into a different bag, how many did he put in this bag?

30. Choose the pair of mathematical statements that best represents this problem. "Obi and Nneka have a total weight of 120kg. Three times Obi's weight is the same as 5 times Nneka's weight. How heavy is each?"

- A.  $3x + 5y = 120, 3x = 5y$
- B.  $x + y = 120, 3x = 5(3x)$
- C.  $3x + 5(3x) = 120, 3x = 5y$
- D.  $x + y = 120, 3x = 5y$



31. Simplify

$$\frac{2x}{x^2 + xy} - \frac{3y}{x^2 + yx} + \frac{y - 2x}{x^2 - y^2}$$

A.  $\frac{3y^2 - 4xy}{x^3 - xy^2}$

B.  $(3y - 4x)(x^2 - y^2)$

C.  $(3y^2 - 4xy)(x^2 + 2xy + y^2)$

D.  $\frac{3y - 4x}{x^3 - xy^2}$

32. If  $x = -1$  and  $y = 2$  What is the value of  $\frac{1}{(x - 1)(y + 2)}$

A. 0

B.  $\frac{1}{8}$

C.  $-\frac{1}{8}$

D.  $-\frac{1}{4}$

33. If  $\frac{x - 6}{13} - \frac{3 - 2x}{14} = \frac{7}{12}$ , then  $x$  is

A. -1.5

B. 19

C. 7.5

D. 18

34. Expand (but do not simplify)  $x(x + \frac{1}{x}) - 2(\frac{1}{2x} - 2)$

A.  $x^2 + \frac{1}{x^2} + \frac{1}{x} + 4$

B.  $x^2 + 1 - \frac{1}{x} + 4$

C.  $x^2 + 1 - \frac{1}{x} - 4$

D.  $x^2 + 1 + \frac{1}{x^2} + 4$

.../7.

35. Factorise  $ab^3 - abc^2$  completely:

- A.  $a(b^3 - bc^2)$
- B.  $b(ab^2 - ac^2)$
- C.  $ab(b - c)(b + c)$
- D.  $ab(b^2 - c^2)$

36. Which of these statements is false? ✓

- A.  $-25 < 1$
- B.  $0 > -1$
- C.  $-1 > 0$  ✓
- D.  $0.997 < 1$

37. Find the solution set of this inequality  $\frac{6}{x} \geq 3$

- A.  $0 < x < 2$
- B.  $0 \leq x \leq 2$
- C.  $0 < x < 2$
- D.  $0 \leq x \leq 2$

38. What are the coordinates of the point A



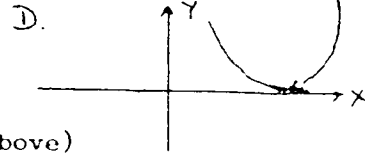
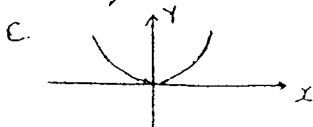
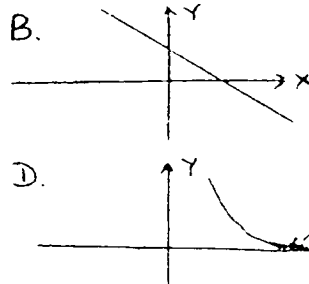
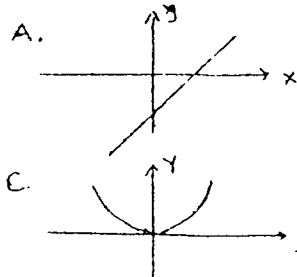
- A.  $(-x, y)$
- B.  $(x, -y)$
- C.  $(-x, -y)$
- D.  $(x, y)$

39. If  $3x - 2y = 7$  which set of numbers taken in order correctly completes this table?

x	0	1	2	3	4	5
y						

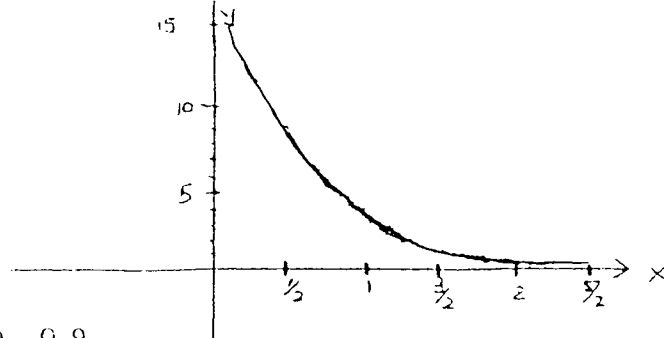
- A. 7, 5, 3, 1, -1, -3
- B.  $-3\frac{1}{2}$ , -2,  $-\frac{1}{2}$ , 1,  $2\frac{1}{2}$ , 4
- C.  $-3\frac{1}{2}$ , 0, -1,  $-\frac{1}{2}$ , -2, 4
- D. 0, 1, 2, 3, 4, 5

40. If  $3x - 2y = 7$ , then the graph of  $y$  with respect to  $x$  looks like:-



(Use the table in question 39 above)

41. From this graph what is the approximate value of  $y$  when  $x = 0.5$  ?



- A. 0.9
- B. 9
- C. 5.9
- D. 9.9

42. Solve the simultaneous equation  $3x + 2y = 12$ ;  $5x - 3y = 1$ .

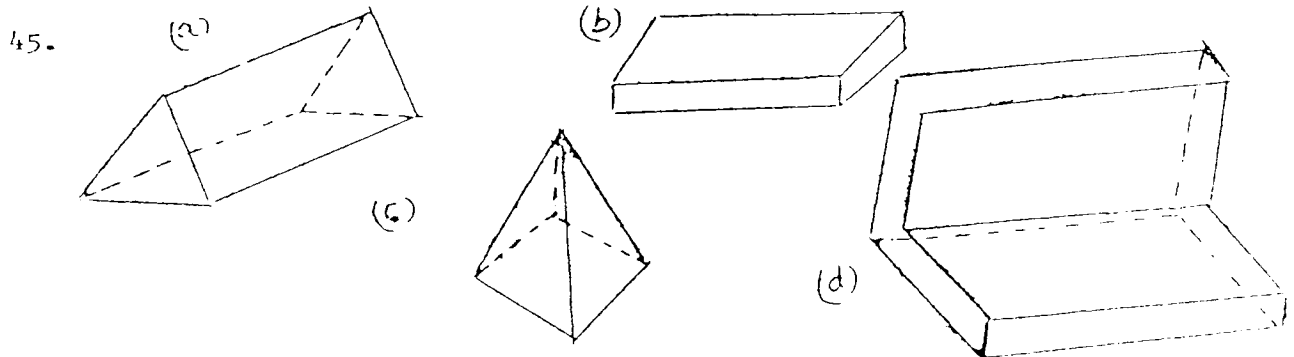
- A.  $x = 2, y = 3$
- B.  $x = 3, y = 2$
- C.  $x = -3, y = 2$
- D.  $x = -2, y = 3$

43. The mass of copper wire varies jointly upon its length and the square of its diameter. If 500m of wire of diameter 3mm has a mass of 31.5kg, what will be the mass of 1km of wire of diameter 2mm?

- A. 14kg
- B. 28kg
- C. 31kg
- D. 31.5kg

44. If  $\frac{1}{u} = \frac{1}{a} + \frac{1}{ab} + \frac{1}{b}$ , then express b as a function of u and a

- A.  $b = au \frac{(a + u)}{(a - 1)}$
- B.  $b = \frac{a}{u} \frac{(a - 1)}{(a - u)}$
- C.  $b = \frac{1}{au} \frac{(a - u)}{(a + 1)}$
- D.  $b = u \frac{(a + 1)}{(a - u)}$



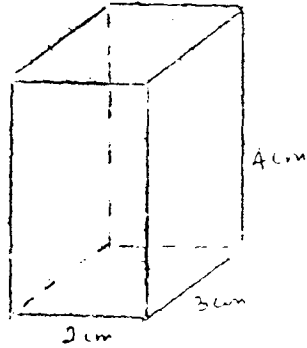
Which of the following statements is TRUE about the 3 - D shapes above?

- A. a and d are prisms
  - B. a, b, and c are prisms
  - C. a, c, and d are prisms
  - D. a and c are pyramids.
46. Which of the following statements is FALSE?
- A. A triangle with no edges the same length is called a scalene triangle.
  - B. A quadrilateral with four edges the same length is called a rhombus.
  - C. A square is a special kind of rectangle.
  - D. A quadrilateral with at least two pairs of parallel edges is called a parallelogram.
47. The perimeter of a polygon is
- A. equal to the circumference of the circle circumscribing it.
  - B. the sum of the lengths of the sides.
  - C. the union of the non-overlapping inscribed triangles.
  - D.  $\pi$  multiplied by the square of the radius.

48. The area of a plane figure is :-

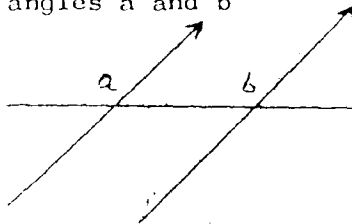
- A. The length times the width
- B. Two times the length plus the width.
- C. The amount of space covered by the plane figure measured in square units.
- D. None of the above.

49. What is the volume of this figure?



- A.  $9 \text{ cm}^3$
- B.  $24 \text{ cm}^3$
- C.  $24 \text{ cm}^2$
- D.  $9 \text{ cm}^2$

50. Identify the pair of angles a and b



- A. Adjacent angles.
- B. Alternate angles
- C. Corresponding angles
- D. Vertically opposite angles.

51. Which of the following sets of lengths (cm) cannot form the sides of a triangle?

- A. 7.4, 12.5, 5.01
- B. 2.0, 2.5, 1.5
- C. 16.5, 16.5, 17.5
- D. 5.5, 5.5, 5.5.

52. Each of the exterior angles of a regular convex polygon is  $15^\circ$ . How many sides has the polygon?

- A. 15
- B. 24
- C. 36
- D. 48

53. A triangular plot of land has sides 152m, 208m and 178m. Which set of lengths in (cm) must a draughtsman use if he is to draw the plan of this land on a scale of 1cm to 20m?

- A. 1, 2.3, 7.9
- B. 7.6, 10.4, 8.9
- C. 3.9, 10.2, 7.8
- D. 15.2, 20.8, 17.8

54. The actual dimensions of the rectangular piece of land below drawn to scale 1cm to 20,000m is approximately equal to:-



- A. 5.5m by 1.5m
- B. 158000m by 40000m
- C. 110000m by 30,000m
- D. 17500m by 30,000m

55. The angle of elevation of the top of a vertical pole is  $45^\circ$  from a point A. If the foot of the pole is 201 metres from A, find the height of the pole in metres.

- A. 402
- B. 201
- C. 20.1
- D. 102

56. A boat sails 2km N, then 3km NE and finally 2km E. What is its new bearing from its starting point?

- A. NNE
- B. NE.E
- C. NE
- D. S.W.

57. How far is the boat from its starting point?

- A. 5.83 km
- B. 7 km
- C. 4.2 km
- D. 6.3 km

58. Which of the following ratios are appropriate for the sides of a right-angled triangle?

- A. 6: 11: 8
- B. 8: 9 : 10
- C. 7: 12: 13
- D. 5: 12: 13 ✓

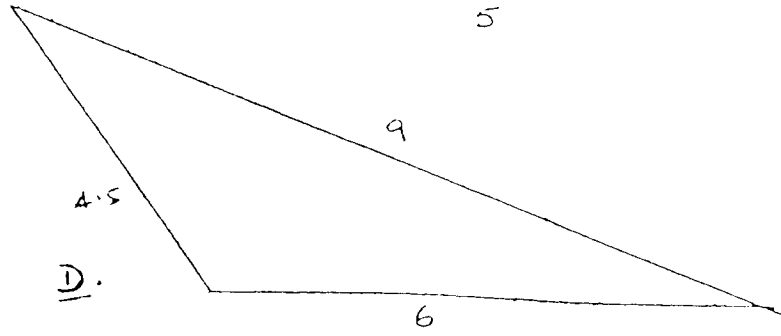
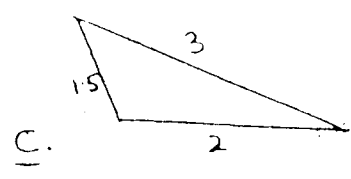
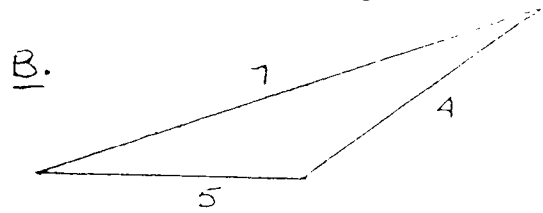
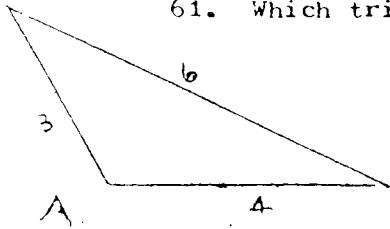
59. A gymnasium of height 6m length 23m and with 15m is to be painted. What is the total area of the surface to be painted if the floor only is to be excluded?

- A. 1146 m<sup>2</sup>
- B. 801 m<sup>2</sup>
- C. 257 m<sup>2</sup>
- D. 1087 m<sup>2</sup>

60. A soft drink company sells its soft drink in cans with a cross sectorial radius of 3.5cm and a height of 13cm. If 1 cubic cm of soft drink represents 1 milliliter then how many liters would the tin hold if full?

- A. .64
- B. 0.286
- C. 5
- D. 0.5

61. Which triangle below is not similar to the other triangles?



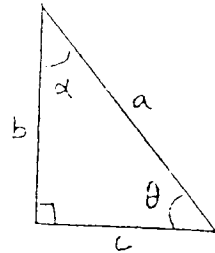
.../13.

62. Draw  $\overline{BT}$  so that  $\widehat{CBT} = 50^\circ$  and  $\overline{BC} = 6\text{cm}$ . At B draw a line perpendicular to  $\overline{BT}$ , to meet the perpendicular bisector of  $\overline{BC}$  at O. Then the circle with centre O and radius  $\overline{OB}$  contains the required arc. The above describes a correct method for constructing:

- A. A segment of a circle 6 cm long subtending an angle  $50^\circ$  at the centre.
- B. An arc of a circle to contain an angle of  $50^\circ$  on a line  $\overline{BC}$  6cm long.
- C. An arc BC of a circle 6cm long subtending an angle  $50^\circ$  at the centre.
- D. A sector of a circle with chord  $\overline{BC}$  6cm long whose perpendicular bisector make an angle  $50^\circ$  at the centre O.

63. Which of the following statements is FALSE?

- A.  $\frac{b}{c} = \tan \theta$
- B.  $\frac{a}{h} = \sin \alpha$
- C.  $\frac{c}{a} = \cos \theta$
- D.  $\frac{c}{b} = \tan \alpha$



64. 8.4, 8.3, 8.4, 8.1, 8.3, 8.2, 8.4, 8.3, 8.2, 8.4, 8.1, 8.2,

The mode, median and mean of the data above are respectively

- A. 8.1, 8.3, 8.3
- B. 8.2, 8.1, 8.275
- C. 8.4, 8.275, 8.3
- D. 8.4, 8.3, 8.275

65. Two coins are tossed. The probability that both will land heads up is

- A.  $\frac{1}{2}$
- B.  $\frac{1}{4}$
- C.  $\frac{1}{3}$
- D. 2

66. Which of the following statements is False?

- A. The mode, median and mean each help to describe a set.
- B. The mode, median and mean each is used to give an average value of the members of a set.
- C. The mode, median and mean are measures of central tendency.
- D. The mode, median and mean each is a measure of how frequent the average value occurs.



67. Standard deviation is ✓

- A. A measure of central tendency.
- B. A measure of dispersion from the mean.
- C. The deviation from the mode.
- D. None of the above.

68. Simplify  $\frac{3^a \times 9^{a+1}}{27^{a-1}}$

- A.  $3^5$  ✓
- B.  $32^a$
- C. 1
- D.  $a + 1$

69. What is x if  $2 \log_3 3 + 4 \log_{10}^2 = 2 + \log_{10} x$

- A. 1.44
- B. 3.6
- C. 4.0
- D. 14.4

70. Use log tables to evaluate  $\sqrt[3]{\frac{218}{3.12}}$

- A. 4.119
- B. 3.45
- C. 24.72
- D. 3.989

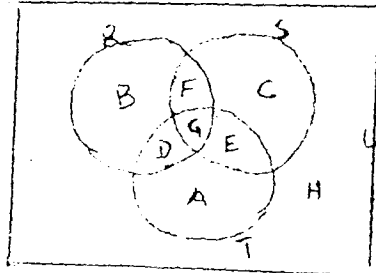
71. Choose the set notation that is best represented by the sentence "R<sup>+</sup> is the set of all positive real numbers"

- A.  $R^+ = \{x \mid x \in R \text{ and } x > 0\}$
- B.  $R^+ = \{x \in R \text{ and } 1 \leq x \leq n\}$
- C.  $R^+ = \{x \mid x \text{ is a real number}\}$
- D.  $R^+ = \{x \mid x \in R^+\}$

72. Let  $R =$  (my friends)  
 $S =$  (students at F.A.T.C.)  
 $T =$  (People from Pankshin)

In which of the spaces A to H in the Venn Diagram below will John be if

- (a) All my friends go to F.A.T.C.
- (b) John comes from Pankshin.
- (c) John is not my friend.
- (d) None of the students at FATC comes from Pankshin.
- (e) I am a student at F.A.T.C.



Answer \_\_\_\_\_

73. What is the  $n^{\text{th}}$  term in this Sequence  $\frac{2}{1}, \frac{3}{2}, \frac{4}{3}, \dots$  ?

- A.  $\frac{n + 2}{2}$
- B.  $1 + \frac{n - 2}{n}$
- C.  $\frac{n}{n - 1}$
- D.  $\frac{n + 1}{n}$

74. Evaluate  $\frac{\log 243 \times \log 64}{\log 9 \times \log 8}$

- A.  $\log 216$
- B. 5
- C.  $\log 5$
- D.  $\log 18.05$

75. The quadratic equation  $4y^2 + 5y - 21 = 0$  can be solved by expressing it as

- A.  $(y - 3)(4y + 7) = 0$
- B.  $(4y - 3)(y + 7) = 0$
- C.  $(y + 3)(4y - 7) = 0$
- D.  $(4y - 5)(y - 21) = 0$

76. What must be added to both sides of  $x^2 - 8x + 3 = 0$  so that the equation can be put in the form  $(x - a)^2 = b$

- A. 13 ✓
- B. 16
- C. -17
- D. 18

77. Solve the following equations  $x + \frac{1}{2}y = 1$ ,  $\frac{1}{3}x - y = 5$

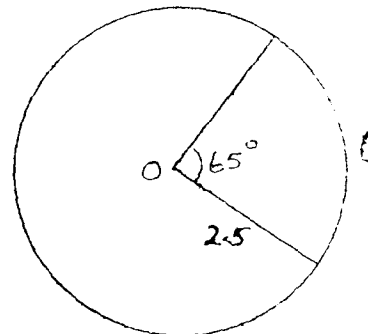
- A.  $x = 1, y = 2$
- B.  $x = 7, y = 3$
- C.  $x = 3, y = -4$
- D.  $x = 3, y = -7$

78. Choose the pair of equation that best represents this word problem.

"A boat can go 3km upstream in 20 minutes, and 3km downstream in 12 minutes. Find the speed of the current, and of the boat in still water."

- A.  $3x + y = 20$   
 $x + 3y = 12$
- B.  $x + y = 20$   
 $3x + 3y = 12$
- C.  $y - x = 9$   
 $y + x = 15$
- D. None of the above.

79. The length (L) of the arc and area (A) of the sector in the diagram are respectively



- A. 3.5 cm and  $3.7 \text{ cm}^2$
- B. 2.836 cm and  $3.545 \text{ cm}^2$
- C. 15.0 cm and  $45.32 \text{ cm}^2$
- D. 2.83 cm and  $3.93 \text{ cm}^2$

80. Which of the following statements in Euclidean Geometry is FALSE?

- A. A line parallel to one side of a triangle divides the other two sides in the same ratio.
- B. The angle which an arc subtends at the centre is twice the angle it subtends at the circumference.
- C. Angle at centre of a circle is half the angle at the circumference.
- D. Opposite angles of a cyclic quadrilateral are supplementary.

81. Theorem: The angle in a semicircle is a right angle.

Proof: Given that  $\overline{AB}$  is the diameter of a circle centre  $O$  is .....(1)

$x$  is any point on the circumference .....(2)

To prove  $\widehat{AXB} = 90^\circ$  .....(3)

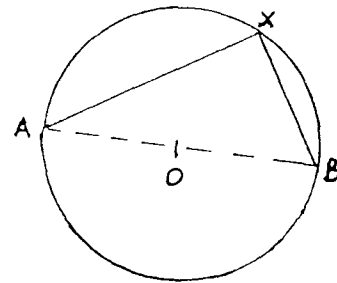
Proof But  $\widehat{AOB} = 180^\circ$  .....(4)

$\therefore \widehat{AOB} = 2\widehat{AXB}$  .....(5)

$\therefore 2\widehat{AXB} = 180^\circ$  .....(6)

$\therefore \widehat{AXB} = 90^\circ$  .....(7)

QED.



Which of the following statements is true about the above proof?

- A. The proof is correct as it appears above.
- B. The proof would be correct if we interchange lines (4) and (5) ✓
- C. The proof follows a logical deduction except that line 5 is primarily false.
- D. The proof is correct except that the original assumption in line (1) is false.

82. Find the approximate distance, measured along the parallel of latitude, between two points whose latitudes are both  $56^\circ N$ , and whose longitudes are respectively  $23^\circ E$  and  $17^\circ W$ .

- A. 1000 km
- B. 2490 km
- C. 51000 km
- D. 1,796,000 km

-18-

83. If ABC is a triangle such that  $AB = 4\text{cm}$ ,  $BC = 3\text{cm}$  and  $CA = 5\text{cm}$  and

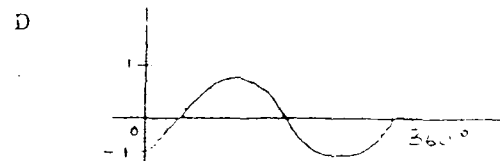
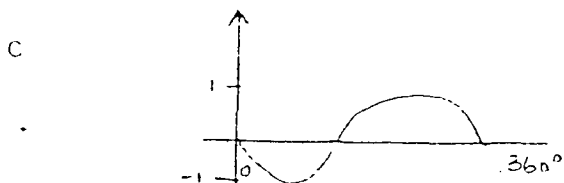
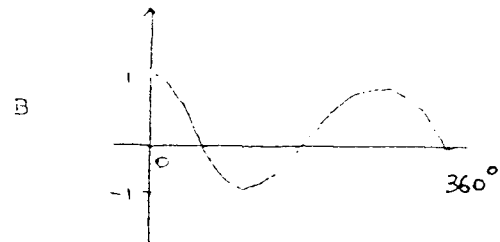
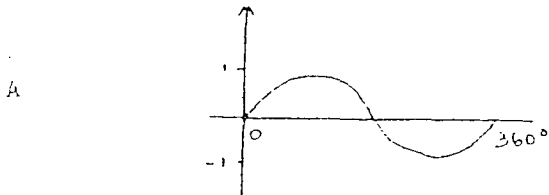
$$\frac{\sin A}{3} = \frac{\sin B}{x}, \text{ the } x \text{ is equal to}$$

- A. 0.2
- B. 3.0
- C. 0.3
- D. 5

84. Which of the following is FALSE?

- A.  $\sin 30^\circ = \frac{1}{2}$
- B.  $\cos 90^\circ = 0$
- C.  $\tan 90^\circ = 1$
- D.  $\cos 60^\circ = \frac{1}{2}$

85. Choose the graph which best represents the graph of  $\sin x$  for values of  $x$  between  $0^\circ$  and  $360^\circ$



86. The equation of all ~~the~~ lines perpendicular to the line  $y = 3x + 6$ , where  $b$  is constant, is

- A.  $y = 3x + b$
- B.  $y = 1/3x + b$
- C.  $y = -1/3x + b$
- D.  $y = 1/6x + b$

87. If the three angles of a triangle are in the proportion 2:5:5, find the angles of the triangle in that order

- A.  $30^\circ, 75^\circ, 75^\circ$  ✓
- B.  $60^\circ, 150^\circ, 150^\circ$
- C.  $40^\circ, 70^\circ, 70^\circ$
- D.  $80^\circ, 50^\circ, 50^\circ$

88. Find the equation of all the lines parallel to the line  $y = \frac{1}{2}x + 5$

- A.  $y = -2x + 2$
- B.  $y = \frac{1}{2}x - 5$
- C.  $y = \frac{1}{2}x + \frac{1}{5}$
- D.  $y = \frac{1}{2}x + b, \quad b \in \mathbb{R}$

89. PQR is a triangle. A point x moves in such a way that x passes through the mid-point of every line segment YZ whose ends Y, Z lie on PQ and PR where YZ is parallel to QR. What is the locus of x?

- A. The bisector of the angle QPR
- B. The altitude through P
- C. The median through P
- D. The line through P parallel to QR

90. What is the sum of the roots of the equation  $2x^2 + x - 6 = 0$ ?

- A. -1
- B. 1
- C.  $-\frac{1}{2}$
- D.  $\frac{1}{2}$

91. Convert the number  $103000_{(5)}$  (base 5) to a number in base 7

- A. 17071
- B. 105000
- C. 13130
- D. 640

92. Express 0.0035 in the standard index form.

- A.  $35 \times 10^{-4}$
- B.  $3.5 \times 10^{-3}$
- C.  $3.5 \times 10^3$
- D.  $35 \times 10^4$

93. Simplify  $\frac{1 + \sqrt{2}}{2\sqrt{2} - 3}$

- A.  $-(7 + 5\sqrt{2})$
- B.  $(2\sqrt{2} - 1)$
- C.  $(7 - 5\sqrt{2})$
- D. None of the above.

94. The total surface area (s) of a closed cylinder is the sum of the areas of the two circular ends and the curved surface. Put this statement in symbols.

- A.  $S = 2\pi r^2 + 2\pi r h$
- B.  $S = \pi r^2 h + 2\pi r$
- C.  $S = 2\pi r^2 + S$
- D.  $S = 2\pi r^2 + \pi r h$

where r is the radius of the base  
h is the height of the cylinder.

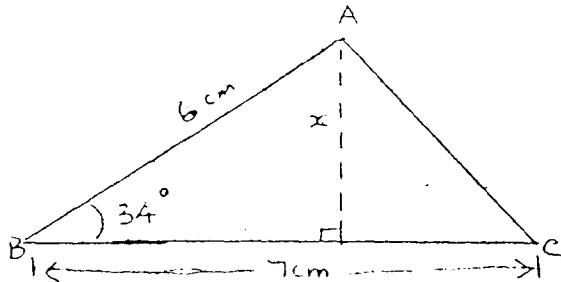
95. Solve the equation  $9^x - 2(3^x) + 1 = 0$

- A.  $x = 3$
- B.  $x = 2$
- C.  $x = 4$
- D.  $x = 0$

96. If ABC is an isosceles triangle such that  $\overline{AB} = \overline{AC} = 5\text{cm}$  and  $\angle BAC = 54^\circ$ . Find the length in cm of the base BC correct to three decimal places.

- A. 6
- B. 4.540
- C. 3.575
- D. 7.01

97. Find the area of  $\triangle ABC$  correct to 2 decimal places



- A.  $24.85 \text{ cm}^2$
- B.  $15.23 \text{ cm}^2$
- C.  $10.82 \text{ cm}^2$
- D.  $11.74 \text{ cm}^2$

-21-

98. What would be the angle at the centre of a pie chart to show the number of women in the table below.

Men	Women	Boys	Girls
140	180	310	270

- A.  $180^\circ$   
B.  $65^\circ$   
C.  $80^\circ$   
D.  $72^\circ$
99. Each exterior angle of an octagon is
- A.  $90^\circ$   
B.  $135^\circ$   
C.  $60^\circ$   
D.  $45^\circ$
100. The length of an arc of a circle of radius 21cm subtending an angle of  $60^\circ$  at the centre is
- A. 231 cm  
B. 22 cm  
C. 44 cm  
D. 66 cm

(Take  $\pi = 22/7$ )





## APPENDIX E

UNIVERSITY OF JOS  
DEPARTMENT OF CURRICULUM STUDIES  
FACULTY OF EDUCATION

Private Mail Bag 2084  
Jos, NIGERIA

Cables & Telegrams: UNIJOS, JOS  
Telephone: (234) 73 55390 Ext. 274

Ag. Head of Department  
Dr (Mrs) A. E. Joof

**Ref.: TEACHER TRAINERS ASSESSMENT OF MATHEMATICS  
PROGRAMMES (TAMP) QUESTIONNAIRE**

*Researcher:* Festus Onyeama Anakwue

Dear colleague,

This questionnaire has been designed to help me obtain the following information:

- Your view of the nature of mathematics teacher education programme in your institution.
- Your perception of teacher education and those issues you consider relevant for inclusion in the curriculum for the education of school mathematics teachers in Nigeria.

Please respond to each of the items in this questionnaire as fully as you can. Your responses shall be handled confidentially and the information provided shall be used for the purpose of this research only.

Please indicate by a tick in the box on the right if you would like a copy of the finding to be sent to you.

SECTION A: PERSONAL DATA

1. Your College \_\_\_\_\_

2. Sex \_\_\_\_\_ 3. Age \_\_\_\_\_ 4. State of Origin \_\_\_\_\_

5. Academic Qualifications (Please put a circle round any of the qualification(s) in the list below that you possess)

WASC	GCE 'O' level	SSC	(TC2)	HSC
OND	GCE 'A' Levels	IJMB	NCE	HNC
HND	BEd	BA(Ed)	BSc(Ed)	BSc
PGDE	PGCE	MEd	MA	MA(Ed)
MSc	MSc(Ed)	PhD	Others(specify) _____	

## 6. Your Rank or Status: (Underline those applicable)

Head of Department	Deputy head of Department	Chief Lecturer
Asst Chief Lecturer	Principal Lecturer	Senior Lecturer
Lecturer I	Lecturer II	Lecturer III
Assistant Lecturer	Other (specify) _____	

## 7. About the Mathematics Department in your college.

- (a) How many people (including yourself) teach mathematics or mathematics education in your college?
- (b) How many of them
- (i) have first degree in mathematics?
  - (ii) have teaching qualifications?
  - (iii) are based in the Maths Dept. ?
- (c) Which other subject(s), apart from education and mathematics, do mathematics student teachers in your college study during their training? \_\_\_\_\_

**SECTION B EXPERIENCES**

(Write YES or NO or give a date or number of years in the boxes as applicable)

8. (a) Have you at any time taught at the secondary, primary school level?
- (b) If YES, for how long  years
- (c) When was the last time you for an in-service course for student teachers?   
(If never, write NEVER in the box)
9. In view of your qualification, do you consider your participation in the training of teachers for mathematics teaching as the most suitable job for you?

**SECTION C PERCEPTION OF TEACHER EDUCATION PROGRAMMES**

10. Describe your understanding of the objectives of mathematics teacher education

11. Do you see the training being given to mathematics student teachers in your institution as appropriate for the task of teaching the core contents of the National Mathematics Curriculum?

12. If your answer to question 11 is NO, please state for which level (primary, junior secondary or senior secondary) they are NOT appropriate.

Give reasons for your answer to question 12 in this box:

13. Please list any three (3) significant features of the training you give to student teachers of mathematics in your college which you consider most important in enhancing their efficiency for the job

14. Please list three things you consider as weaknesses in your mathematics training programme

15. Describe three ways in which your training programme for teachers of mathematics could be improved

APPENDIX F

**CALCULATION OF COHEN'S KAPPA (K)  
FOR INTER-OBSERVER AGREE**

The pattern of agreement and disagreement for 100 observations with two observers can be shown on a two dimensional matrix (often referred to as a "confusion matrix") as follows:

Observer one	Observer two					Total
	A	B	C	D	E	
A	8	0	0	0	0	8
B	2	21	1	0	0	24
C	1	0	18	2	1	22
D	0	0	0	24	6	30
E	1	0	0	1	14	16
Total	12	21	19	27	21	100

The scores on the diagonal from top left to bottom right indicate agreement between the two observers; scores off this diagonal indicate their disagreement.

(1) Proportion of agreement ( $P_o$ ) is given by

$$\frac{(number\ of\ agreements)}{(number\ of\ agreements + number\ of\ disagreements)}$$

which in this case is  $\frac{(8 + 21 + 18 + 24 + 14)}{(100)}$  or 0.85

The index of agreement (or concordance), that is  $P_c$  is simply this proportion expressed as a percentage (i.e. in this case, 85 per cent)

(2) Proportion expected by chance  $P_e$  is based on the probability theory which shows that if the probability of the first observer coding, say, programme A correctly is  $P_{1A}$  and the probability of the second observer coding the same programme A correctly is  $P_{2A}$ , then the probability of both of them coding the same programme correctly by chance is the product of these two separate probabilities (i.e.  $P_{1A} \times P_{2A}$  or  $0.08 \times 0.12$ ). Hence the total chance proportion for all five programmes is

$$P_e = (0.08 \times 0.12) + (0.24 \times 0.21) + (0.22 \times 0.19) + (0.30 \times 0.27) + (0.16 \times 0.21) = 0.262.$$

(3) Cohen's Kappa (K) is the given by the formula

$$K = \frac{P_o - P_e}{1 - P_e}$$

which in this example is

$$K = \frac{0.850 - 0.262}{1 - 0.262} = 0.797$$

APPENDIX G-  
CONTINGENCY TABLES FOR THE CALCULATIONS OF  
CHI-SQUARE  
FOR THE ANALYSIS OF DATA PRESENTED IN  
CHAPTER 6

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENCE AND NOT COMPETENT STUDENT  
TEACHERS AT 80% PERFORMANCE LEVEL IN THE SUBJECT MATTER OF THE NNMC**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	13	2	15
	E			
B	O	19	1	20
	E			
C	O	13	2	15
	E			
D	O	8	2	10
	E			
E	O	23	7	30
	E			
F	O	37	33	70
	E			
G	O	15	5	20
	E			
H	O	23	7	30
	E			
I	O	5	0	5
	E			
J	O	3	2	5
	E			
K	O	11	9	20
	E			
L	O	17	8	25
	E			
TOTALS		187	78	265



**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENCE AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN NUMBER AND NUMERATION (NN)**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	11	4	15
	E	11	4	
B	O	15	5	20
	E	15	5	
		12	3	15
		11	4	
D	O	8	2	10
	E	7	3	
E	O	25	5	30
	E	22	8	
F	O	50	20	70
	E	52	18	
G	O	19	1	20
	E	15	5	
H	O	19	11	30
	E	22	8	
I	O	4	1	5
	E	4	1	
J	O	3	2	5
	E	4	1	
K	O	10	10	20
	E	15	5	
L	O	20	5	25
	E	18	7	
TOTALS		196	69	265

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENT AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN GEOMETRY AND TRIGONOMETRY**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	5	10	15
	E	2	13	
B	O	3	17	20
	E	3	17	
C	O	8	7	15
	E	2	13	
D	O	4	6	10
	E	2	8	
E	O	6	24	30
	E	5	25	
F	O	8	62	70
	E	11	59	
G	O	3	17	20
	E	3	17	
H	O	3	27	30
	E	5	25	
I	O	0	5	5
	E	1	4	
J	O	0	5	5
	E	1	4	
K	O	0	20	20
	E	3	17	
L	O	3	22	25
	E	4	21	
		43	222	265

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENCE AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN ALGEBRA (ALG)**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	14	1	15
	E	12	3	
B	O	19	1	20
	E	16	4	
C	O	14	1	15
	E	12	3	
D	O	8	2	10
	E	8	2	
E	O	25	5	30
	E	24	6	
F	O	54	16	70
	E	57	13	
G	O	17	3	20
	E	16	4	
H	O	24	6	30
	E	24	6	
I	O	4	1	5
	E	4	1	
J	O	5	0	5
	E	4	1	
K	O	13	7	20
	E	16	4	
L	O	18	7	25
	E	20	5	
TOTALS		215	50	265

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENCE AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN DEFINITIONAL AND GENERAL KNOWLEDGE (DGK)**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	11	4	15
	E	9	6	
B	O	15	5	20
	E	13	7	
C	O	11	5	15
	E	9	6	
D	O	6	4	10
	E	6	4	
E	O	22	8	30
	E	19	11	
F	O	36	34	70
	E	44	26	
G	O	13	7	20
	E	13	7	
H	O	22	8	30
	E	19	11	
I	O	3	2	5
	E	3	2	
J	O	2	3	5
	E	3	2	
K	O	11	9	20
	E	13	7	
L	O	15	10	25
	E	16	9	
TOTALS		167	98	265

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENCE AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN PROCESS SKILL**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	8	7	15
	E	7	8	
B	O	14	6	20
	E	10	10	
C	O	10	5	15
	E	7	8	
D	O	8	2	10
	E	5	5	
E	O	15	15	30
	E	14	16	
F	O	26	44	70
	E	33	37	
G	O	10	10	20
	E	10	10	
H	O	13	17	30
	E	14	16	
I	O	2	3	5
	E	2	3	
J	O	3	2	5
	E	2	3	
K	O	5	15	20
	E	10	10	
L	O	12	13	25
	E	12	13	
TOTALS		126	139	265

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENCE AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN PROBLEM SOLVING AND APPLICATION SKILLS (PsAS)**

PROGRAMMES		LEVELS OF UNDERSTANDING		TOTALS
		Competent	Not competent	
A	O	13	2	15
	E	12	3	
B	O	17	3	20
	E	16	4	
C	O	13	2	15
	E	12	3	
D	O	9	1	10
	E	8	2	
E	O	26	4	30
	E	24	6	
F	O	48	22	70
	E	56	14	
G	O	16	4	20
	E	16	4	
H	O	25	5	30
	E	24	6	
I	O	5	0	5
	E	4	1	
J	O	4	1	5
	E	4	1	
K	O	15	5	20
	E	16	4	
L	O	22	3	25
	E	20	5	
TOTALS		212	53	265

**OBSERVED (O) AND EXPECTED (E) NUMBER OF COMPETENT AND NOT COMPETENT STUDENT  
TEACHERS  
AT 80% PERFORMANCE LEVEL IN THE SUBJECT MATTER OF THE NNM  
ACCORDING TO PROGRAMME SETS**

PROGRAMME SETS		LEVELS OF UNDERSTANDING		TOTALS
		Not competent	Competent	
PROG SET 1	O	2	13	15 (5.7%)
	E	4	11	
PROG SET 2	O	10	50	60 (22.6%)
	E	18	42	
PROG SET 3	O	24	76	100 (37.7%)
	E	29	71	
PROG SET 4	O	42	48	90 (34.0%)
	E	27	63	
TOTALS		78 (29.4%)	187 (70.6%)	265 (100%)

APPENDIX H-1

SAMPLE PROGRAMME FOR MATHEMATICS  
TEACHER EDUCATION IN A COLLEGE OF EDUCATION  
IN NIGERIA



**SCIENCE AND TECHNOLOGY**

... of the environment, degradation of the biosphere system and development of the organism, shell, cell, organ, transportation and such as ...  
... of tissue relating to modification of structure, aging and eye lens  
... appreciate that many of the changes that occur with age are natural and may require support and sympathy.

**FIELDS AND WAVES (2 Credits)**

- Force fields
  - Wave motion
  - Electromagnetism
- CARBON COMPOUNDS (1 Credit)**
- Halocarbanes
  - Alkanols
  - Alkanonic acids
  - Amines and amino acids
  - Synthetic macro-molecules

**GLOBAL ECOLOGY (1 Credit)**

The effects on the environment of fuels, food, water, waste disposal,

**1. PHILOSOPHY**  
The philosophy of the subject, mathematics as a pure logic, science, to help students become intellectually informed in mathematical ideas, relations and skills for logical reasoning, scientific enquiry and for the pursuit of techno-scientific education and by the need to produce well-prepared professional teachers of mathematics for our junior secondary and primary schools.

**2. OBJECTIVES**

- (i) At the end of the programme the student will be able to:
  - (i) discuss with confidence the historical development of Mathematics as a discipline,
  - (ii) solve abstract problems through the use of mathematical functions and formulae
  - (iii) motivate pupils' interest in mathematics by the use of appropriate teaching strategies particularly at the primary and junior secondary school levels.
  - (iv) analyse relationships in quantitative terms
  - (v) apply the computer to data processing
  - (vi) demonstrate convincing enthusiasm and intellectual ability for further studies in mathematics.
  - (vii) plan and effectively execute mathematics lessons in junior secondary schools and primary schools.

**3. ADDITIONAL ADMISSION REQUIREMENT**

Candidates seeking for admission into MJC Mathematics should obtain a credit pass in Mathematics at SSC or GCE 'O' level or Merit in TCE.

**4. MODE OF TEACHING**

The teaching of mathematics will be based mainly on lectures, tutorials and problem solving methods. However, courses in methodological approaches such as seminars, demonstration, drill and experimentation will be given. Discovery methods will be emphasized.

**5. FACILITIES**

There must be a mathematics laboratory, mini-computer and a workshop where students can make their own instructional materials.

**6. PERSONNEL**

The student-teacher ratio should be 25:1. There should be an auxiliary staff.

... of Education degree in mathematics or post graduate diploma in Education and a Post Secondary Certificate in Mathematics.  
Second Class (honours) degree in mathematics.

300 MATHEMATICS COURSE  
 MAT 111: Algebra and Geometry (2 Credits)

- Real Number System
- Integers, Rational and Irrational numbers
- Theory of Indices
- Theory of Logarithms
- Surds
- Linear Inequalities
- Partial Fractions
- Theory of Quadratic Equations
- Permutations and Combinations
- Binomial Theorem
- Mathematical Induction
- Complex Numbers
  - Algebra of complex numbers
  - Argand Diagram
  - De Moivre's Theorem
  - $n^{\text{th}}$  roots of Unity
- Set Theory
- Union, Intersection and Complement
- Algebra of Sets
- Binary Logic
- Methods of proofs
- Binary operations
- Circular Measure
  - Trigonometric Functions of angles of any magnitude
  - Addition and Factor Formulae
  - Half angle formulae
  - Solution of Triangles
- Hyperbolic Functions and their Identities

MAT 112: CALCULUS (2 Credits)

- Functions:
- Limit of a function at a point
  - Continuity of a function at a point
  - Gradients of a function
  - The differential coefficient as a gradient of a function at a point.
  - The formula for differential coefficient

COURSE CONTENTS (MAT 111)

Year/Semester	Course Code & Number	Course Title	Credit	Class
I	MAT 111	Algebra & Trigonometry ✓	03	Compulsory
	MAT 112	Calculus ✓	02	Compulsory
	MAT 113	Theory of Mathematics	02	Required
	MAT 114	Basic concepts in Maths	02	Compulsory
1	MAT 121	Vectors and Coordinate Geometry	03	Compulsory
	MAT 122	Mathematics Methodology	02	Compulsory
	MAT 123	Introduction to Computer Studies	02	Required
I	MAT 211	Number Theory	02	Elective
	MAT 212	Mathematical Methodology	03	Compulsory
	MAT 213	Problem Solving	02	Elective
	MAT 221	Statistics & Probability	02	Compulsory
2	MAT 222	Vector Analysis	02	Required
	MAT 311	Dynamics & Studies	03	Compulsory
3	MAT 321	Linear Algebra	03	Required
	MAT 322	Real Analysis	03	Compulsory
	MAT 324	Abstract Algebra	03	Required

SUMMARY

Compulsory (Core)	26 Credits
Required (Cognate)	12
Elective	4
	<b>42 Credits</b>

*Algebraic product and quotient*  
 The area under the curve and the function of a function

- Differentiation of logarithmic functions, trigonometric functions, exponential functions and hyperbolic functions
- Implicit differentiation
- Integration as a reverse process of differentiation
- Integration as area under the curve. Integration of Algebraic functions using different methods, like partial fractions, substitution, etc.
- Integration of non-algebraic functions e.g. logarithmic functions, exponential functions, trigonometric functions, etc
- Special methods of Integrations, substitution and transformation, the reduction formula and other types of systematic integration
- Integration by Parts
- Approximate Integration by Trapezoidal Rule and Simpson's Rule
- Application of Integration in determining Volumes of solids of Revolution and solution to other problems.

**MAT 113:**

**HISTORY OF MATHEMATICS (2 Credits)**

- Pre-historic mathematics
- Development of mathematics in the ancient times
  - Contributions of Babylonians, Greeks, Egyptians, Romans, Hindu-Arab and Chinese
  - Prominent ancient mathematicians and their contributions (Archimedes, Pythagoras of Samos, Euclid, Apollonius, etc)
- Development of mathematics in the middle ages and prominent mathematics of the period.
- The Renaissance and mathematics (16th to 20th centuries) and prominent mathematicians and their contributions (Napier, Fermat, Euler, Riemann, Lebesgue, Lagrange, Hilbert, Bannach, Cauchy)
- The use of mathematics in everyday life including its place in Natural and Applied Sciences. The age of computer science and its application
- Problems and prospects of mathematics education in Nigeria.

**MAT 114:**

**BASIC CONCEPTS IN MATHEMATICS (2 Credits)**

- Sets and set operations
- Fundamental operations
- Number Bases other than 10
- Finite Arithmetic
- Compound Statements - Logical relations
- Matrices
- Determinants
- Games

**Representation of vectors in 1-3 dimensions**

- Equality of vectors
- Position vectors
- Triangular, Parallelogram and Polygon laws of vector addition
- Resultant of vectors
- Associative law of vectors
- Negative and unit vectors
- Scalar or dot product vectors
- The cosine of the angle between two vectors
- Direction cosines
- Modulus of a vector
- Magnitude or length of a vector
- Communicative and distributive laws of vectors
- Co-ordinate Geometry
- Straight line and Circles
- Parabola, Ellipse and Hyperbola in Cartesian, Parametric and polar co-ordinates
- Tangents and normals to the circles
- Parabola, Ellipse and hyperbola (the use of differentiation is acceptable)

**MAT 115: TEACHING MATHEMATICS (C.V.T. / C-Ed-III)**

- History of mathematics teaching in Nigeria and the philosophy of current Nigeria mathematics curricula
- Elements of philosophy of mathematics teaching and learning including works of Bruner, Gagne, Piaget and Dienes
- Brief discussion of taxonomy of objectives and lesson presentations
- Introduction to questioning techniques
- Teaching of concepts, principles, skills and proofs
- Inductive, deductive, analytic and synthetic approaches in mathematics teaching
- Laboratory approaches to teaching mathematics
- Lesson Assessment
  - table of specification
  - item construction and
  - construction of marking scheme
- Diagnosis and remediation of difficulty in mathematics learning.

**MAT 123:**

**INTRODUCTION TO COMPUTER STUDIES (2 Credits)**

- Historical development of the Computer
- Essential components of the Computer and their functions
- Number presentation in a Computer

Student's problem-solving approaches and their applications to problems from Senior Secondary School Mathematics and further Mathematics Curricula.

**MAT 221: STATISTICS AND PROBABILITY (2 Credits)**

- Frequency distribution
- Measures of location
- Measures of dispersion
- Correlation
- Binomial distribution
- Skewness of curves
- z - scores
- Sample space
- Probability laws
- Discrete and continuous distributions
- Distribution function of a random variable
- The binomial, poisson and normal distributions and their various properties.

**MAT 222: VECTOR ANALYSIS (2 Credits)**

- The position vectors (explain using the model of space co-ordinates)
- The magnitudes and modulus of a vector
- The unit vector
- Two-dimensional vector in two or three dimensions (using Cartesian co-ordinates).
- Solar or dot product of two vectors.
- Solar or cross product of two vectors
- Relations between dot product and component of work done in a force field
- Triple products of vectors
- Plane and space curves and their vector equations, Vectors' differentiation
  - the grad. notation
  - the del (or vector operator) notation
- The divergence of a curve vector and the divergence theorem.
- Green-Stokes formulae for solution of problems.

**MAT 311: DYNAMICS AND STATICS (3 Credits)**

- Dynamics
  - Displacement, speed, velocity and acceleration in Cartesian and Polar Co-ordinates
  - Velocity and acceleration along the tangent and normal to it
  - Relative velocity, motion of particles in straight lines
    - Relative velocity of two particles (same or opposite)
  - Projectiles: Time of flight, range on a horizontal plane, greatest height reached, the path of a projectile as a parabola

Data Structures and their uses in a Computer  
 Computer softwares and types of software  
 Basic Programming

Illustration and the application of simple techniques to data processing

**MAT 211: NUMBER THEORY (2 Credits)**

- Further Properties of Integers
  - Well ordering principle
  - Mathematical induction
  - Laws of trichotomy
  - Divisibility (Basic definitions, divisors, primes, gcd, basic theorems on gcd - (proofs may be required)
- Euclidean algorithms and applications (proofs may be required)
- Relatively prime integers (unique factorisation)
- The fundamental theorem of arithmetic (proof may be required).
- Congruences
  - Basic definitions and examples
  - Properties of congruences (reflexive, symmetric and transitive: the equivalence relation)
  - Residue classes
  - Linear congruences
    - Basic theorems and solutions of linear congruences. Proofs of the main theorems may be required
- Fermat's theorem and applications, the proof of Fermat's theorem may be required
- Euler function and number (proofs not required)
- Applications of Linear Congruences

**MAT 212: MATHEMATICS METHODOLOGY II (3 Credits)**

- Teaching of geometrical concepts
- Statistics at JSS level
- Trigonometry at SSS level
- Proofs in Geometry
- Graphs, Variation and Proportion
- 3-dimensional problems including latitudes and longitudes mensuration-areas and volumes
- Common errors in Mathematics

**MAT 213: PROBLEM SOLVING (2 Credits)**

- Generating techniques involving types and functions of questions
- Types of discovering approaches
- Polya's principles of teaching mathematics

- Impact of two smooth spheres (Proof not required)
  - The principle of conservation of energy
- Statics**
- General conditions of equilibrium
  - Resolution of forces acting at a point which are in equilibrium
  - Equilibrium condition of moments
  - Coplanar forces
  - Centre of gravity: centre of mass, simple forms, general formula for centre of gravity.
  - Compound bodies, centre of gravity by integration.
  - Friction: laws of friction, angle of friction, the least force problem, problems involving sliding only.

**MAT 321:**

**LINEAR ALGEBRA (3 Credits)**

- Determinants**
- Vector space over the real field, subspace, linear independence, basis and dimension
- Linear transformations and their representational matrices; range, null space, rank, singular and non-singular transformation and matrices.
- System of Linear equations, change of basis equivalence and similarity.
- Eigen values (latent roots) and eigenvectors (latent vectors)
- Minimax and characteristic polynomials of a linear transformation (matrix)
- Cayley - Hamilton theorem

**MAT 322:**

**REAL ANALYSIS (3 Credits)**

- Basic properties of real number system including boundedness and completeness, Concept of neighbourhood,
- Open and closed sets
- Basic theorems on open and closed sets
- De Morgan laws
- Function and functional notation
- Rigorous treatment of limits and continuity
- L'Hospital's rule (proof may be required)
- Consequences of differentiation
- Rolle's Theorem**
- Mean value theorem and Taylor's theorem (proof may be required)
- Successive differentiation
- Leibnitz's formula for  $n^{\text{th}}$  derivative (proof not required)
- Functions of Several variables
- Partial differentiation

**Integration**

- Definition of Riemann Integral**
- Properties of Integrals and basic theorems (Proof of the fundamental theorem of calculus may be required)
- Multiple integration:** elementary treatment of the Fubini's theorem in the plane
- Series and Sequences**
- Monotonic and Cauchy sequences
- Rigorous treatment of tests for convergence is expected.
- Proof of Boundedness, Comparison, Ratio and Root tests may be required**
- Absolute And Conditional Convergence**
- Radius of Convergence**
- Power series**
- Uniform Convergence**

**MAT 323:**

**DIFFERENTIAL EQUATIONS (2 Credits)**

- First Order Differential Equation**
- Existence and uniqueness of solution
  - Examples to be limited to equations of the types:
    - (i)  $\frac{dy}{dx} = f(x), \frac{dy}{dx} = f(y)$
    - (ii)  $\frac{dy}{dx} = f(x) \cdot g(y)$
  - Solutions by variable separation restricted only to easy integral
- Homogeneous equations**
- Exact equations, and integrating factor for non-exact equations**
- (iii) Solution of 2nd order differential equation.
- Example to be restricted to the equations of the type:
- (a)  $\frac{d^2y}{dx^2} = F(X),$  (b)  $\frac{d^2y}{dx^2} = -w^2 y$

**With boundary conditions**

- Equations with constant coefficients and Cauchy - Euler types should be treated
- Formulation of equations from physical situations

**MAT 324:**

**ABSTRACT ALGEBRA (3 Credits)**

**Algebraic structures:**

- Groupoid, Semigroup, Monoid and group, Subgroup, Lagranges' theorem; Cyclic group, Ring. Integral domain, division ring and field
- polynomials: polynomial rings, the division algorithm for polynomials, HCF and LCM of polynomials
- Factorisation.

APPENDIX H-2  
INFORMATION UNDER EIGHT HEADINGS EXTRACTED  
FROM SAMPLE PROGRAMMES

Table 4.1. INFORMATION UNDER EIGHT HEADINGS EXTRACTED FROM SAMPLED PROGRAMMES

PROG GROUP	ENTRY REQUIREMENT	METHOD OF SELECTION	DURATION AND MODE OF TRAINING	SCHEME OF STUDIES	EVALUATION AND ASSESSMENT PROCEDURE	TEACHING PRACTICE ARRANGEMENT	CERTIFICATION REQUIREMENT	TARGET DESTINATION OF GRADUATES
A	Minimum of five credits in SSC/GCE <sup>1</sup> or TC2 <sup>2</sup> two of which must be in mathematics and English language	No interview in the process of selection	3 years full-time (5 semesters <sup>3</sup> of academic work plus one semester of teaching practice)	Modular system. Choice of modules in all semesters. GS <sup>4</sup> courses are however compulsory for all students.	Modules are assessed during the semester in which they are taken.	One by six weeks teaching in each of the fourth and sixth semesters (12 weeks)	At least 72 credits worth of modules plus completion of a project	Primary and Junior Secondary
B	Credit passes in mathematics and English and a science subject in of GCE/SSC/TC2	Oral interviews testing general knowledge are used in final selection exercise.	3 years full-time (8 terms <sup>5</sup> of academic work and approx. one term of teaching practice)	All first year courses and all GS courses are compulsory. Choice of modules is available only in the second and third year of training	First year and all GS courses are examined at the end of first year. Other modules are assessed termly.	Six weeks teaching in each of the sixth and eight terms	At least a pass in each of the first year and GS courses plus a minimum of 48 credits worth of modules from the second and third year choices plus a project Min. 72	Primary and Junior Secondary
C	Minimum of three credits and two passes with at least two credits in mathematics and English from SSC/GCE/TC2	Interviews are used for final selection	3 years full-time (5 semesters of academic work plus 1 semester of teaching practice)	Modular system. Only GS courses are compulsory but could be taken anytime at students' convenience.	Modules are assessed during the semester in which they are taken.	One teaching practice exercise of six weeks in each of the fourth and sixth semesters	Minimum of 72 credits worth of modules plus satisfactory completion of a project in maths education.	Primary and Junior secondary
D	Minimum of two credit passes in English and mathematics plus at least a pass in three other subjects at SSC/GCE/TC2	No interviews at any stage during selection process.	3 years full-time which includes one 12 weeks teaching practice exercise. operates semester system	GS courses only are compulsory and are offered as first two semesters. Choice of other modules is available.	GS courses are assessed at the end of second semester. Other modules are assessed when taken	One twelve weeks long teaching practice exercise in a secondary school in the sixth semester	Minimum of 90 credits worth of modules plus satisfactory completion of a project in mathematics education.	Junior Secondary only

<sup>1</sup> SSC = Senior School Certificate. GCE = General Certificate of Education<sup>2</sup> TC2 = Teachers' Grade 2 Certificate<sup>3</sup> One semester is 18 weeks long with 12 weeks of teaching, one week of revision and two weeks for examinations and submission of major pieces of course-works and projects.<sup>4</sup> GS courses = General Studies courses (i.e. use of English, philosophy and logic, history of science and Nigerian peoples and culture).<sup>5</sup> One term is 13 weeks long with 10 weeks of teaching. Most secondary schools in Nigeria operate the term system

<b>E</b>	Five credit passes in SSC/GCE or five merit passes in TC2 (including maths & English) plus at least two years teaching experience for TC2 entrants.	Common entrance examination conducted by JAMB <sup>6</sup> . No interviews	3 years full-time or 5 years part-time (6 or 10 semesters of academic work including 12 weeks of T.P.	Choice of modules available. GS courses are however compulsory.	Modules are assessed during the semester in which they are taken.	Two by six weeks teaching practice taken either in the sixth or tenth semester.	Minimum of 90 credits worth of modules plus satisfactory completion of a project in mathematics education.	Junior Secondary
<b>F</b>	TC2 with at least two merit passes or GCE/SSC with at least three credit passes in English and maths or any other qualification deemed acceptable by the HOD (Maths) with at least two years teaching experience.	Oral interview and/or an aptitude test or entrance qualifying examination as appropriate.	3 years full-time and 5 years part-time for entrants with good TC2, GCE or SSC. Others 2 or 4 years full-time or 4 and six years part-time depending on qualification and experience on entry. Operates semester system.	Choice from modules arranged in four levels. TC2 and GCE/SSC entrants choose from levels 2 to 4, entrants with lower qualifications take all level 1 courses plus choices from levels 2 to 4. Others (e.g. A level entrants) choose from the last two levels.	Modules are assessed during the semester in which they are taken except that entrants with lower qualification must obtain at least a pass in all level 1 modules before proceeding to other levels.	One academic year (or two semesters) spent as school-based training. Students spend the last year of training teaching. Some consultation with college is done	Min. of 78 credits for TC2/GCE/SSC entrants; 102 credits for entrants with lower entry qualifications and 52 credits for entrants with 'A' levels or equivalent qualifications.	Primary and/or Junior secondary depending on status and choice on admission.
<b>G</b>	Credits in maths and English plus at least passes in three other subjects at TC2/GCE/SSC.	Common entrance examination conducted by the college	3 year full-time (6 semesters of academic work including 12 weeks of teaching practice)	Choice of modules. GS courses in first semester only	Modules are assessed during the semester in which they are taken	Two by six weeks teaching practice in a secondary school One in the fourth semester and one in the sixth	Minimum of 102 credits worth of modules plus a project in maths education, maths or education.	Junior secondary only.
<b>H</b>	Minimum of three credits and two passes with at least a credit in maths and English) at TC2, GCE or SSC.	Interviews are used for final selection	3 years full-time or 5 years part-time (9 or 15 terms as appropriate)	Choice of modules available GS courses can be taken any time	Modules are assessed at the end term in which they are taken	One academic year (or two semesters) spent as school-based training. Students spend the last year of training teaching. Some consultation with college is done	Minimum of 102 credits worth of modules plus satisfactory completion of a project.	Primary and Junior Secondary.
<b>I</b>	Minimum of two credit passes in English and mathematics plus at least a pass in three other subjects	No interviews at any stage during selection process.	3 years full-time which includes one 12 weeks teaching practice exercise.	GS courses only are compulsory and are offered as first two semesters. Choice of	GS courses are assessed at the end of second semester. Other modules are	One twelve weeks long teaching practice exercise in a secondary school	Minimum of 90 credits worth of modules plus satisfactory completion of a project in	Junior Secondary only

<sup>6</sup> JAMB = Joint Admission and Matriculation Board/



	at SSC/GCE/TC2			other modules is available.	assessed when taken	in the sixth semester.	mathematics education.	
J	Minimum of three credits and two passes with at least a credit in maths and English) at TC2, GCE or SSC.	Interviews are used for final selection	3 years full-time or 5 years part-time (9 or 15 terms as appropriate)	Choice of modules available GS courses can be taken any time	Modules are assessed at the end term in which they are taken	One academic year (or two semesters) spent as school-based training. Students spend the last year of training teaching. Some consultation with college is done	Minimum of 102 credits worth of modules plus satisfactory completion of a project.	Primary and Junior Secondary.
K	TC2 with at least two merit passes or GCE/SSC with at least three credit passes in English and maths or any other qualification deemed acceptable by the HOD (Maths) with at least two years teaching experience.	Oral interview and/or an aptitude test or entrance qualifying examination as appropriate.	3 years full-time and 5 years part-time for entrants with good TC2, GCE or SSC. Others 2 or 4 years full-time or 4 and six years part-time depending on qualification and experience on entry. Operates semester system	Choice from modules arranged in four levels. TC2 and GCE/SSC entrants choose from levels 2 to 4, entrants with lower qualifications take all level 1 courses plus choices from levels 2 to 4. Others (e.g. A level entrants) choose from the last two levels.	Modules are assessed during the semester in which they are taken except that entrants with lower qualification must obtain at least a pass in all level 1 modules before proceeding to other levels.	One academic year (or two semesters) spent as school-based training. Students spend the last year of training teaching. Some consultation with college is done	Min. of 78 credits for TC2/GCE/SSC entrants; 102 credits for entrants with lower entry qualifications and 62 credits for entrants with 'A' levels or equivalent qualifications.	Primary and/or Junior secondary depending on status and choice on admission.
L	Credit passes in mathematics and English and a science subject in of GCE/SSC/TC2	Oral interviews testing general knowledge are used in final selection exercise.	3 years full-time (8 terms of academic work and approx. one term of teaching practice)	All first year courses and all GS courses are compulsory. Choice of modules is available only in the second and third year of training	First year and all GS courses are examined at the end of first year. Other modules are assessed termly.	Six weeks teaching in each of the sixth and eight terms	At least a pass in each of the first year and GS courses plus a minimum of 48 credits worth of modules from the second and third year choices plus a project	Primary and Junior Secondary

APPENDIX I  
STUDENT TEACHERS' RAW SCORES  
ON THE  
SMCT

STD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	21	22	23	24	26	27	29	30	31	32	34	35	36			
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55	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
56	1	1	1	1	0	0	1	1																											





















0	1	0	1	1	1	0	1	0	1	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	
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APPENDIX J

MAP OF NIGERIA

(INDICATING FIELDWORK CENTRES FOR EACH ZONE)

MAP REDACTED DUE TO THIRD PARTY RIGHTS OR OTHER LEGAL ISSUES

