At Seventh Form level, Applied and Pure Mathematics are supposed to be alternatives, although in practice almost all who take Applied also take Pure Mathematics. (There are current proposals to change this.) In the ambitious Statistics section of the Applied Mathematics prescription are: Conditional probability, expectation algebra, hypergeometric, Poisson and normal distributions, least squares regression (with standard errors), hypothesis testing, confidence intervals, the *t*-test, tests based on the chi-squared distribution.

PART 4

Africa

CHAPTER 10

Some Problems of the Teaching of Statistics in Developing Countries – The Nigeria Example

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Most English-speaking countries in Africa, which are now independent, had a common colonial master – Great Britain. Each country therefore had an educational system which was similar to that in another English-speaking country.

Nigeria is a federation of nineteen states, diverse in size, population, economic, social, cultural and educational development. It is by far the most populous of the former African colonies of Great Britain. There are no accurate population figures but estimates put the population at about eighty million. Thus much of the planning is done without the necessary statistics. Twenty-three years ago when universal primary education was introduced into what was then the Western Region of Nigeria, it turned out that nearly twice the projected number of pupils registered for the first year of the scheme. This created a problem for the officials who had made provision for only half of those who eventually registered. This kind of problem also manifests itself in other social services. For example, a hospital may be planned for a particular locality with a given population in mind and it may occur that the facilities provided in it are inadequate for the population for which the hospital was built. Planning without accurate figures is a common feature of the economy of most developing countries.

10.1 THE EDUCATIONAL SYSTEM IN NIGERIA

In most parts of the nineteen states of Nigeria primary schools offer a six-year course while secondary grammar schools offer a five-year course leading to the West African School Certificate Examination. This is followed, in a selected number of schools, by a two-year Higher School Certificate Course to provide further education for the more able students. The two-year Higher School Certificate programme is sometimes given in Schools of Basic Studies attached to some of the Universities or in the Polytechnics or Schools of Arts and Science. There are also Commerical and Technical Schools as well as Modern Schools.

Each of the nineteen states of the Federation has its own Ministry of Education which controls the schools (primary, secondary and post-secondary) in the state. Each has its own syllabuses for the different school subjects. The Federal Government, at the moment, has exclusive jurisdiction over University education. However, in the new Constitution, provision has been

made for the states to have concurrent legislative powers for University education. Until recently, the Federal Government did not interfere with the powers of the States over primary and post-primary education. With the introduction of the Universal Free Primary Education and the participation of the Federal Government in funding it, however, there has been some central direction in relation to syllabuses for primary and secondary schools and teacher training colleges. These new syllabuses which have been produced under the sponsorship of the Nigerian Educational Research Council and the Federal Ministry of Education are, at the moment, merely guidelines and have not been imposed. It may very well be that in the future the Federal Government may require some amount of uniformity. However, most of the states are modelling their syllabuses along the lines of the syllabuses recommended by the Nigerian Educational Research Council and the Federal Ministry of Education.

10.2 STATISTICS IN NIGERIAN SCHOOLS

10.2.1 *Primary Schools*

Until quite recently most primary school syllabuses did not contain anything in Statistics. The recommended syllabus in mathematics contains the following topics in statistics.

Everyday Statistics
Primary III (Grade III)
Content: Pictogram; mode
Objectives: Pupils will be able to:
(a) read pictograms and show information in pictograms using vertical and horizontal arrangements
(b) identify the most common value from a pictogram.
Primary IV (Grade IV)
Content: Further work on pictogram and bar graphs; mode.
Objectives: Pupils will be able to read and prepare bar graphs.
Primary V (Grade V)
Content: Further work on pictogram and bar graphs.
Preparing a tally and using it to make a table.
Experiments on coin tossing and dice throwing.
The mode and the mean.
Objectives: Pupils will be able to:
(i) draw bar graphs and pictograms
(ii) prepare tables for graph work
(iii) record in a table experiments on coin tossing and dice throwing
(iv) calculate the mean of data.
Primary VI (Grade VI)
Content: Pictograms and bar graphs. Interpretation of pictograms and bar graphs. Mode and Mean
Objectives: Pupils will be able to:
(i) interpret pictograms and bar graphs

(ii) calculate the mean of data and identify its mode and to decide which one of the two gives better information about the data.

Thus the statistics syllabus for the primary school may be summarised as:

Representation of data in pictograms and bar graphs. The mean and the mode. Some elementary idea of uncertainty – experiments with throwing a die and tossing a coin. NO attempt is made to introduce any of these ideas earlier than in Primary III (Grade III) or to give any systematic treatment of combinatorics or of probability theory. The primary school syllabuses in mathematics in most of the states do not include as much statistics as in the Nigerian Education Research Council Syllabus which will in time be adopted by all the states. Also only a few of the texts in mathematics for the primary school contain anything in statistics except for bar graphs. Many of the teachers. who themselves had no courses in statistics at school, are unable to teach even the elementary material, listed above, effectively.

There is no common School Leaving Examination at the end of the six-year primary school course. Each state sets its own examination. However, there is a National Common Entrance Examination to Secondary Schools which is taken in many states of the Federation. The Mathematics (or Arithmetic) Paper often has simple questions on graphical representation of data.

10.2.2 *Secondary Schools*

The content of Statistics courses in secondary schools in Nigeria is dictated by the requirements of the West African School Certificate Examination. Some statistics forms a part of the mathematics syllabus. While mathematics is compulsory for all pupils taking the West African School Certificate Examination it is possible to pass the examination in mathematics creditably without answering any questions in statistics.

Statistics is offered in four or five different forms in the secondary grammar school. First, it is taken as a part of the so-called traditional mathematics. The examination in this subject consists of two papers. Paper I is taken by all three categories of candidates – General, Commercial and Technical. Paper II is in the main different for each category of candidates but has some common features.

Mathematics (Ordinary Level)
Paper I (General, Commercial, Technical)
Statistics
Presentation of data by pie and bar charts. Arithmetic mean, median and mode (excluding grouped data). Calculation of arithmetic mean for a given set of numbers. Finding the median and mode for a set of numbers. Frequency distribution and histogram.
Paper II (Commercial)
Statistics
Measures of location and dispersion:
Arithmetic mean, median and mode. Calculation of arithmetic mean for

a given set of numbers and for grouped data. Finding the median and mode for a set of numbers.
Estimation of mode from histogram. Range, interpercentile ranges, semi-interquartile range; variance and standard deviation for a set of numbers and for grouped data.
Calculation and use of simple index numbers. Moving averages.

Secondly, statistics formed a part of the Modern Mathematics (Ordinary Level) Syllabus. It may be remarked that Modern Mathematics is no longer offered as a subject in the West African School Certificate Examination in Nigeria since 1979, even though it continues to be offered in Ghana, Sierra Leone, Gambia and Liberia. The portion on statistics in the Modern Mathematics Syllabus is:

Statistics: graphical representation – frequency: mean, mode and median.
Simple probability: involving equally likely events.

Thirdly, there are two alternative papers in Additional Mathematics, namely: Additional Mathematics (Ordinary Level) and Additional Modern Mathematics (Ordinary Level). Additional Mathematics is an optional subject, and is taught only in schools where there is an adequate mathematics staff and where sufficient interest in mathematics has been generated among the pupils.

Additional Mathematics (Ordinary Level) is the so-called Traditional Additional Mathematics. Examination in each of two papers in the subject is made up of two parts: Section A – which consists of five simple compulsory questions in elementary calculus, trigonometry, algebra and statistics. Section B has six slightly more difficult questions in Pure Mathematics, Statistics and Mechanics. It is quite possible to get a good pass in Traditional Additional Mathematics without answering any questions in statistics. Also the number of pupils offering the subject is small compared with the total number of candidates.

The syllabus in Statistics in *Additional Mathematics* is as follows.

Section A

The classification and tabulation of statistical data e.g. population, trade, growth of plants, examination marks. Pictorial representation, e.g. pie charts, bar charts of frequency diagrams, mean, median, mode and quartiles. Measurement of dispersion by range and the interquartile range. Interpretation and application of statistical data.

Section B

Statistics

Histogram, including cases of unequal class intervals and its relationship with the cumulative frequency diagram. Moving averages, index numbers, measurement of dispersion by the standard deviation, use of an assumed mean (change of origin) in calculating the standard deviation. The relationship between frequency and probability.
The addition and multiplication laws of probability with simple illustrations.
Frequency and probability distributions. The Binomial Distribution.

The statistics syllabus in *Additional Modern Mathematics*, which is given below, is slightly different from that for traditional mathematics. It includes some probability. Here again, it is possible to pass the subject without answering questions in statistics. Also the number of pupils offering Additional Modern Mathematics is small, being an optional subject.

Statistics

Tabulation and graphical presentation of data. Histograms (including unequal class intervals).
Mode, median, mean: including use of assumed mean and calculation of mean from class frequencies.

Probability

Simple problems on probability, involving both equally and non-equally likely events. Sum and product laws, simple cases of conditional probability.

Fourthly, there is a small section on Statistics in the General Paper of the Higher School Certificate Examination and the mathematics syllabus of the General Certificate of Education Examination (Advanced Level). The syllabus in statistics for the *General Paper* is:

Interpretation of graphical, diagrammatical or tabular presentation of facts. There will be a choice of questions.

The syllabus in statistics which forms a part of the *Mathematics (Advanced Level)* paper is given below

Syllabus	*Notes*
(The questions set will test application of method, use of method and inference rather than mere mechanical calculation.)	
Frequency distributions, frequency density, histograms, cumulative frequency diagrams.	Pictorial representation
Central tendency; dispersion. Measures of central tendency.	Mean, median, mode, percentiles and quartiles. Range, variance, standard deviation.
Measures of dispersion. Calculation of these measures from a set of numbers and from a frequency distribution.	Calculation of mode from a frequency distribution only.
Arrangements and selections. Frequency interpretation of probability. Laws of probability, probability density, cumulative probability.	Dependent and independent events.
Binomial and Poisson distribution.	Situations illustrating these distributions; formal derivations of mean and standard deviation not required.

Rectangular and Normal distributions as examples of continuous distributions.	Application to rounding-off errors.
Meaning of correlation and regression.	
Scatter diagrams.	Linear regression only
Graphical treatment of regression.	
Rank correlation.	

Finally, a few years ago, the West African Examinations Council proposed *Statistics* as a subject in its own right in the West African School Certificate Examination. So far only a few candidates offer this subject. The syllabus which appears below covers the usual topics found in most elementary courses in Statistics.

Syllabus

Topic	*Notes*
A. Collection of Data	
1. Nature of statistical investigations. Range of problems requiring the statistical method.	The inductive nature of statistical reasoning, i.e. finding general rules and general characteristics from (a limited number of) specific observations.
2. Sources of statistical data. Objectives. Scope and planning of Census and Surveys: pilot enquiries.	Examples to be drawn from population, housing, agriculture and industry.
3. Basic ideas of random and non-random sampling. Quota sampling and other forms of systematic and subjective sampling as examples of non-random sampling.	Distinguish between sample and population. Illustrate with simple examples.
4. Units and methods of enumeration.	Person, household as units. Interviewer and mail questionnaire as examples of methods of enumeration.
Simple ideas on the design of questionnaires.	Types of questions, e.g. closed, semi-closed and opened. Candidates will be expected to decide, among given alternatives, what type of question is most suitable for a specific enquiry. Reference to type of question should be by means of an example and NOT simply by the use of a technical term.

Post-enumeration surveys.	Their aims and merits.
B. Tabulation and Presentation of Data	
5. Frequency distributions. Grouping of data. Relative, and percentage, frequencies.	Use of class intervals (including unequal class intervals). Correction for rounded-off data, e.g. a measurement of 6.5 cm means that the reading lies between 6.45 and 6.55 cm.
Cumulative frequency distributions	
6. Frequency polygons, histograms and cumulative frequency polygons (ogives).	See also paragraph 8 (Section C)
7. Bar diagrams, pie charts, and pictograms. Population maps using dots of varying density.	
Graphs of series of observations.	e.g. time series.
C. Measures of Location and Dispersion	
8. Arithmetic mean, median and mode. Calculation of arithmetic mean for a given set of numbers and for grouped data.	Use and suitability of the different measures of location. Use of the (sigma) notation and subscripts. $\sum_{1}^{n} x_i = x_1 + x_2 + x_3 + \ldots + x_n$
Finding the median and mode for a set of numbers.	Use of assumed mean and a scaling factor e.g. $y = \frac{x - a}{k}$
Estimation of median, quartiles and percentiles of grouped data from cumulative frequency graphs.	
Estimation of mode from histogram.	
9. Range, interpercentile ranges, semi-interquartile range, variance and standard deviation for a set of numbers and for grouped data.	Use and suitability of the different measures of dispersion. Use of assumed mean and scaling factor.
D. Probability and Probability Distributions	
10. Meaning of Probability. Numerical calculation of probabilities in simple situations.	Relative frequency interpretation of probability. Random arrangements and selections.
11. Binomial and normal distributions. Use of normal distribution tables.	Mathematical derivation of the mean and standard deviation not required.

Simple significance testing.	Simple test on binomial populations.
	Sample inspection.
Confidence intervals for means of normal population.	Test for means of large samples from normal population.
E. Bivariate Data	
12. Representation by scatter diagram. Graphical treatment of regression and correlation. Fitting regression line to scatter diagrams by eye and the determination of its equation $y = mx + c$ by calculating its slope and reading off the intercept.	Meaning and use of regression coefficient. Mathematical derivation of regression coefficient not required.
13. Definition (by formula) and calculation of the product moment correlation coefficient r. Interpretation of r. Rank correlation: Spearman's coefficient $= \frac{1 - 6\Sigma d^2}{N(N^2 - 1)}$	Interpretation of positive and negative values of r. The significance of values of r close to 1 and values of r near zero. In the case of tied ranks the convention of giving the arithmetic mean rank to each of the equal items will be used.
F. Time Series, Weighted Averages, Index Numbers	
14. Elementary analysis of time series. Secular trend and seasonal cycles.	Use of moving averages to remove seasonal variations.
15. Weighted averages	Crude and standardised birth and death rates.
	Consumer and wholesale price indices (see 16)
16. Index Numbers and their uses. Consumer and wholesale price indices; value, volume, and quantity indices	

The syllabus of Teacher Training Colleges in mathematics contains very little statistics. This is not a satisfactory state of affairs since the teaching of statistics in Primary Schools cannot improve until teachers in training are given a good foundation in statistics.

Of the thirteeen Universities in Nigeria only two, at the moment, have separate departments of statistics. The others run joint courses in statistics with the mathematics, or some other, departments. One University offers training for professional serving officers from Government departments. One of the constraints on the establishment of separate departments of statistics in Universities is the acute shortage of statisticians who could fill vacancies in the Universities.

10.3 NEEDS AND PROSPECTS

Some of the problems of the teaching of statistics in developing countries may be stated as follows.

10.3.1 *Lack of qualified teachers*

For a long time to come the teaching of statistics in developing countries will be a part of the various mathematics programmes. If it is difficult in most developing countries to find teachers of mathematics, it is more difficult to find teachers of statistics. The reason for this is not far to seek. Many teachers of mathematics did not have any statistics courses during their training and so are not able to give effective leadership in the teaching of statistics. One way of correcting this deficiency is to ensure that the curriculum of Teacher Training Colleges in mathematics does contain a good foundation in statistics so that the teachers in training may have adequate preparation for their future work. The curriculum for Teacher Training Colleges in mathematics in Nigeria does not, at the moment, contain enough material in statistics. Teachers of statistics also need the kind of help which a journal like *Teaching Statistics* can give.

10.3.2 *Textbooks*

Textbooks in elementary statistics suitable for use in primary and secondary schools are practically non-existent. Most of the books do not contain examples which are not culture-free. There is need for a series of books similar to the series *Statistics by Examples* (Mosteller, *et al*, Eds., 1973, Addison-Wesley, Reading, Mass., USA) specifically written for developing countries. Examples used in such a series will have to be taken from real-life situations in the different countries. Such a writing programme will need to be sponsored by ISI or by UNESCO.

10.3.3 *Teaching aids*

The usual teaching aids which are taken for granted in developed countries are practically non-existent in most developing countries.

Television is a powerful tool in teaching if it is properly used. Most schools in Nigeria do not, at the moment, have access to educational programmes on television. One reason for this lack of electricity or irregularity in the supply of power. Often when there is money to buy a television set it soon falls into disuse due to lack of proper maintenance.

Professor Varga of Hungary has, in collaboration with another author, developed *'Mathematische Labor'* for the teaching of combinatorics and probability theory. If the *Laboratory* can be cheaply produced or adapted for use in developing countries then the teaching of statistics would be greatly enhanced.

The pocket calculator is now in common use in many countries where they are produced or sold cheaply. Pocket calculators are sometimes used in

some primary school programmes such as the Comprehensive School Mathematics Programme developed by CEMREL, Inc., For a long time to come it does not appear that pocket calculators can be sold cheaply enough for every secondary school child in Nigeria to be able to buy one.* The use of the computer for statistical work is not within reach of many developing countries.

A committee could be set up to look into the needs of developing countries for the production of teaching aids. Apart from the television, films and film-strips will also be found useful for the teaching of statistics but they have to be carefully produced.

10.3.4 *The curriculum*

Most developed countries are experimenting and improving their curricula all the time. Unfortunately there is not enough experimentation going on in Nigeria. Experiments in developing new curricula do take time and are expensive. It is not often that developing countries can divert much-needed funds to experimentation. Some of the well tested programmes on the teaching of statistics may be adopted for use in selected areas in developing countries.

10.3.5 *Need for visiting lecturers*

There is need for specialist lecturers who can generate interest in the teaching of statistics to pay periodic visits to developing countries to help out with various statistical programmes – be it the training of teachers, or of other users of statistics. Even at the University level there is an acute shortage of statisticians to run courses in the Universities. Help is therefore needed also at the University level. One way to do this is for Universities in developing countries to enter into agreements with Universities in developed countries whereby Professors can go to Universities in developing countries for short periods to help in building up strong departments of statistics. Universities in developed countries might also offer places to students from developing countries to train.

* Since this report was prepared pocket calculators have become easily available in Nigeria. For ₦ 10 or ₦ 15 it is possible to buy a simple calculator.

CHAPTER 11

Statistical Education in Schools in Uganda and Other East African States

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11.1 HISTORICAL BACKGROUND

Formal education was introduced in Uganda about 90 years ago by the Christian missionaries and later by the colonial administration. Education then was of a rudimentary nature and consisted largely of learning how to read, write, simple arithmetic, English grammar, Swahili, hygiene, and religious education. It was also designed primarily for sons (and later daughters) of local Kings and Chiefs, and schools were segregated according to religion. Thus when time came – about 1915 – to move a step forward and formalize the educational system into primary, secondary and technical sectors, the few Church of England secondary schools which emerged then, and for about 40 years to follow, were modelled on the lines of English public schools like Eton and Harrow. The Roman Catholic ones were modelled along the lines of the country of origin of the missionaries – France or Italy. Not surprisingly, therefore, when Makerere University was established in Kampala as a College for Higher Learning in East and Central Africa in 1922, it was also done along the lines of Oxford/Cambridge (Oxbridge). The essential point that emerges, therefore, is that up to the late fifties, the educational system of Uganda and other East African states was closely linked with that of English institutions. The University of Cambridge did the final examining for secondary schools (awarding the well-known O-level and A-level certificates) and the (then) Makerere College operated as a College of the University of London. This point has a direct bearing on the current state of the teaching of statistics in schools in this region as we shall see below.

Just before independence – at the end of the fifties – the then colonial administration saw it fit to depart from the Christian-missionary-dominated Eton-type schools and start Government-owned schools where formalism and classics were pruned down to a bare minimum and emphasis was put more on experimentation and innovation. However, before long these schools, too, were 'sucked' into the stream as they had to conform to standards dictated by the O-level examining body, namely the Examinations Syndicate of the University of Cambridge.

Four things happened after independence in all the three East African states:

(i) schools were desegregated so that pupils could cross the boundaries of religion in (up to then) largely missionary schools;