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 Commercial 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 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:
  1. read pictograms and show information in pictograms using vertical and horizontal arrangements
  2. 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.
- **Objectives:** Pupils will be able to:
  1. draw bar graphs and pictograms
  2. prepare tables for graph work
  3. record in a table experiments on coin tossing and dice throwing
  4. 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:
  1. interpret pictograms and bar graphs
  2. 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:
  1. 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

The questions set will test application of method, use of method and inference rather than mere mechanical calculation.)

Frequency distribution, frequency density, histograms, cumulative frequency diagrams.

Central tendency; dispersion. Measures of central tendency.

Measures of dispersion. Calculation of these measures from a set of numbers and from a frequency distribution.

Arrangements and selections. Frequency interpretation of probability. Laws of probability, probability density, cumulative probability.

Binomial and Poisson distribution.

Notes

Pictorial representation

Mean, median, mode, percentiles and quartiles. Range, variance, standard deviation.

Calculation of mode from a frequency distribution only.

Dependent and independent events.

Situations illustrating these distributions; formal derivations of mean and standard deviation not required.
Rectangular and Normal distributions as examples of continuous distributions.
Meaning of correlation and regression.
Scatter diagrams.
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**

A. Collection of Data

1. Nature of statistical investigations. Range of problems requiring the statistical method.


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.

4. Units and methods of enumeration.

Simple ideas on the design of questionnaires.

Application to rounding-off errors.

Linear regression only

Notes

The inductive nature of statistical reasoning, i.e. finding general rules and general characteristics from (a limited number of) specific observations.

Examples to be drawn from population, housing, agriculture and industry.

Distinguish between sample and population. Illustrate with simple examples.

Person, household as units. Interviewer and mail questionnaire as examples of methods of enumeration.

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.

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Reference to type of question should be by means of an example and NOT simply by the use of a technical term.
Simple significance testing.

Confidence intervals for means of 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.
13. Definition (by formula) and calculation of the product moment correlation coefficient \( r \). Interpretation of \( r \).
Rank correlation: Spearman's coefficient
\[ r_s = \frac{1 - 6 \sum d^2}{N(N^2 - 1)} \]
F. Time Series, Weighted Averages, Index Numbers
15. Weighted averages

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 thirteen 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.

Simple test on binomial populations.
Sample inspection.
Test for means of large samples from normal population.

Meaning and use of regression coefficient. Mathematical derivation of regression coefficient not required.

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.

Interpreting correlation coefficient not required.

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.