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THE INTEGRATION OF STATISTICS AND ITS
IMPLICATIONS FOR TEACHING

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The Integration of statistics and its
implications for teaching

Introduction

1. As statistics developed, the subject became diverse and its fields of specialization numerous. One of the outcomes of this diversity was the communications gap among different groups of statisticians. As the gap widened, concerned statisticians addressed themselves to the problem of how to bridge it.

2. At its fortieth session in Warsaw in 1975, the International Statistical Institute addressed itself to the problem by appointing a committee on the integration of statistics. The committee identified different aspects of the communications gap, i.e. the gap between theoretical and applied statisticians and between various branches of theory as well as gaps within various groups of practising statisticians. ^{1/} The committee compiled the following list of 15 categories of statisticians:

Academic	{including university, college, school}
Business	{including actuarial, marketing, economic, econometr
Government	{including federal, State, local, municipal}
Industrial	{including operations researcher, quality controller, reliability worker, physical, engineering, transport}
Practitioner	{including applied statistics, data analyst}
Research	{including applied statistics, methodological, theoretical, mathematical, probabilist}
Student	
Biometric	{including ecological, agricultural, forestry}
Medical	{including biostatistician, health, epidemiologist, pharmaceutical}
Social	{including demographic, political, judicial, criminal behavioral, psycholological}
Administrator	{including manager, policy former, planner, forecaster, auditor}
Consulting	
Computational	{including simulator, computer programmer, package writer}
Survey	{including pollster}
Other	{including sports, numerologist}

3. It should be noted that the above categorization does not imply that it is the only one which can be used to describe the different types of statisticians. Nor does it mean that every statistician falls into one and only one of the above categories. It is not unusual, for example, for a theoretical statistician

^{1/} International Statistical Institute. Report of the International Statistical Institute Committee on the Integration of Statistics

to be engaged also in research as well as consulting. The communications gap can best be illustrated by looking at the work of the academic statistician and comparing it with that of the government statistician. The former is engaged mainly in teaching theoretical statistics with or without any applications. In the case where applications are considered an integral part of the academic course, the type of applied statistics taught tends generally to be artificial and in many cases far removed from the realities of everyday life. There may be a few exceptions to this general rule depending on the knowledge and practical experience of the academic statistician. The government statistician in Africa however is concerned mainly with official statistics. This over the years has tended to be routine and in most cases removed from recent developments in the field of statistics. Thus over a period a gulf builds up between the academic and government statistician. The former with some justification regards the latter as lacking in the basic skills relating to the state of the art and the government statistician views the academic statistician, also with justification, as being generally too theoretical to contribute anything useful towards the improvement of official statistics.

Causes of the gaps

4. The main cause of the gaps among different kinds of statisticians is, as already identified, lack of communication. Another cause is probably the methods of statistical education. In this connexion, the ISI Committee addressed itself to two main questions:

(a) How present methods of education and training of statisticians contribute to the problem;

(b) Whether and how specialization contributes to the problem.

In the following paragraphs an attempt will be made to answer these two questions against the background of the situation in Africa. However, it should be noted that this is a global issue. At the ninth Conference of Commonwealth Statisticians convened in Nairobi, Kenya, from 25 November to 6 December 1980, it was agreed that "for one reason or another, the educational system of most countries do not produce people with the right training for work in a government statistical office."^{2/}

5. Most of the training given at the middle and intermediate levels (certificate and diploma) occur in institutions which in theory at least are heavily weighted towards applications. Unfortunately, as most of the lecturers do not have recent first hand experience of working in the field of applications (especially in the public sectors) it is not always possible to adhere to the principle of meaningful practical orientation of the courses in these centres. However, it is in the area of professional training (undergraduate and higher) that the problem becomes even more acute. All statistical training in English-speaking countries at this level occurs in universities where the education can very often tend to be theoretical. A few centres have tried to stress applications in their courses but the general state of statistical education in the universities cannot be regarded as satisfactory as far as the practical orientation of courses is concerned.

^{2/} Ninth Conference of Commonwealth Statisticians. Summary of proceedings. Nairobi. 1980.

6. In post-graduate courses, the position is even worse as the following two examples will show. In the M.Sc. programme at the University of Ghana, the following are the possible courses:

- S.400: Statistical theory
- S.401: Probability theory
- S.402: Stochastic processes
- S.403: Linear statistical models
- S.404: Non-parametric statistics
- S.405: Multivariate analysis
- S.406: Analysis of discrete data
- S.407: Introduction to biostatistics
- S.410: Seminars

In the first year, each student is expected to offer S.400, S.401, and S.402. In the second year, two courses can be selected together with S.410 and a project. It is obvious from the course content that, with the exception of the individual projects which may involve practical data analysis, the student may complete a good M.Sc. degree in statistics without being useful as a government statistician. This reaffirms the view expressed by the Conference of Commonwealth Statisticians, referred to earlier. However it is necessary to indicate that the purpose of a M.Sc. course is not necessarily to train persons for work in government statistical offices but usually rather to equip candidates for work in industries or to provide as the initial stage of training for an academic career.

7. The second example is taken from the University of Ibadan, Nigeria, where the courses for the M.Sc. degree are as follows:

- STA 451 Practical project
- STA 461 General statistical theory
- STA 462 Advanced statistical methods
- STA 463 Design and analysis of experiments
- STA 464 Design and analysis of sample surveys
- STA 465 Time series
- STA 466 Mathematical programming and game theory
- STA 467 Advanced econometric methods
- STA 468 Advanced demographic analysis
- STA 469 Advanced biometric methods
- STA 470 Topics in the methodology of official statistics

Candidates are expected to offer STA 451, 461 and 462 and in addition any two of the remainder. It would appear that in Ibadan an effort has been made to bridge the gap but this is not enough. The question to be asked is whether a better approach towards the integration of statistics could not have been achieved by relating some aspects of official statistics to the theoretical work instead of treating them as separate units. It is also relevant to note that the shorter list of electives in Ghana could be due to the problems of staffing currently facing the university.

8. Under the French system, the certificate and diploma courses are similar to those in equivalent institutes for English-speaking countries. It is at the professional training courses that differences occur. It is difficult to establish exact equivalences between the French levels and the English. For purposes of general comparison, the Ingenieur des travaux statistiques (ITS) and the Ingénieur statisticien économiste (ISE) correspond to the B.Sc. and M.Sc. in statistics but there are important differences which are not relevant to this paper. The strict professional training occurs at statistical training institutes rather than at universities, although universities also offer statistical courses. The training at statistical centres is generally oriented towards applications and to that extent cannot be blamed for the lack of statistical integration. However there is some specialization at this level at all the French-speaking centres except at the Institut africain et mauricien de statistique et d'économie appliquée (IAMSEA) Kigali. The following are the fields of specialization in the three remaining centres:

1. Institut de statistique, de planification et d'économie appliquée (ISPEA), (Yaoundé)
 Planning and applied economics or statistics
2. Ecole de statistique d'Abidjan (Abidjan)
 Informatics or
 Management or
 Demography or
 Applied statistics
3. Institut des techniques de planification et d'économie appliquée (ITPEA), (Algiers)
 Economic analysis or
 Statistics
4. Institut national de statistique et d'économie appliquée (INSEA), (Rabat)
 Studies and research (small groups on special topics in third year)

Thus even at that level there is room for improvement as indicated below. It is after the ITS course that specialization begins. There are two main courses open to an ITS graduate desiring formal qualification oriented training to do a course for either ISE or demography. This is the stage for specialization and that is where most of the gaps attributable to training occur. It should however be noted that the options in the first year of ISE at CESD are intended to correct potential weaknesses in candidates and that, after this first year, the two groups are regarded as having obtained the same form of training in preparation for entry into the second year. This is different from arrangements at the Rabat centre where specialization begins early. For the ISE course at Centre européen de formation des statisticiens économistes des pays en développement (CESD), the arrangements are as follows:

1st year

ECONOMICS OPTION

Mathematics (topology and differential calculus, analysis and integral calculus, algebra, convex theory)

Statistics and probability (probability theory, calculus of probability, decision theory, descriptive statistics)

Economics (Introduction to micro-economic theory, economics)

Others (Introduction to informatics, language)

MATHEMATICS OPTION

Mathematics (compulsory mathematics, multi-criteria optimisation and game theory or complex analysis and stochastic processes, convex theory)

Statistics and probability (calculus of probability, theory of probability, decision theory, descriptive statistics)

Economics (descriptive economics, introduction to micro-economics, economics)

Others (introduction to enterprise accounts, introduction to informatics, languages).

2nd year

Mathematics (linear programming and convex theory)

Statistics (applied statistics, mathematical statistics, economic and social statistics)

Economics (economic theory, preparation and presentation of seminar papers, problems of development in the Third World, National accounts, budget and public finance)

Others (demography, sociology of development, introduction to enterprise accounts, introduction to informatics, language).

3rd year

Compulsory core (data analysis, econometrics, theory and practice of sampling, planning and choice of projects, economics and international institutions, compilation of survey results)

Options

Mathematics of statistics theory (mathematical programming theory of graphs, numerical analysis, non-parametric statistics, analysis of variance and design of experiments, stochastic processes, analysis and forecasts of time series, econometric models using simultaneous equations, processes of the second order).

Economics (Monetary and international economics, introduction to Marxist economic theory, theory of planning, development economics, public economics, applied sociology, rural economics and agricultural statistics, seminar on political economics, national plans, estimates and short-term forecasts, administrative institutions, economic budgets).

Statistical practice (statistical informatics, analysis - programming survey practice)

Enterprise Economics (economic calculations in enterprises) optimal control applied to economic calculations methodology of accounts and management, financial management, enterprise economics, marketing, commercial laws, control of manufactured products).

It appears also from the ISE course that specialization especially in the third year could, as in the case of postgraduate courses at English-speaking centres, contribute to the communications gap.

9. As is obvious from above, specialization contributes to the problem of the communication gap since the educational system at this level fails to stress the interrelationships of theories and applications in one field with those of other areas. A case is not being made here against specialization; that would be fatal to the cause of statistical development. Instead a plea is being made for a slight modification in course content and in the method of teaching to show that each specialist is aware in a general way of some of the major developments in other fields and is able to appreciate similarities to sectors within his own area of specialization. The question of how this is to be done is dealt with below.

Possible approaches to the solution of problem

10. In view of the causes of the communications gap between statisticians of different kinds discussed in the previous section, it is necessary to consider how far reorientation of present training methods can assist in solving the problem. It is necessary to consider this from three angles: the certificate, the diploma and the professional courses. At the certificate and diploma course levels, there is at present not a great deal of specialization in the training institutes in the region. For example, in the proposed Guide syllabuses prepared for the certificate level courses all students are expected to undertake general courses in economics, mathematics, statistical theory and methods and applied statistics together with the necessary laboratory work and the field project. There is no provision for specialization at that level. At the diploma level the same mix of subjects is proposed. Thus at the end of training both at the certificate and the diploma levels the students would have acquired a general background in theoretical and applied statistics which should enable them to work as supporting staff in any of the branches of statistics enumerated in paragraph 2 above. Modifications are however possible, mainly

through the integration of courses on applied statistics and also through more emphasis on applications. The project work could also be used as a mechanism for demonstrating the integration of statistics.

11. It is when consideration is given to the orientation of courses at the professional training level that the problem of the academic bias of these courses becomes acute. As already discussed in the previous section, conditions vary between English-speaking and French-speaking countries and also within each of the two language groups. The problem will therefore be considered specifically from the angle of the two main language groups.

12. The English-speaking training centres, as mentioned in paragraph 5, are located in universities and are guided by the same academic standards as for other sections of the university. It is necessary to consider the options which are now available. Some of these universities have a straight-forward degree course in statistics with the areas of specialization being determined by the available staff. The greater the number of staff and expertise available the more likely that candidates will specialize in one or two narrow areas. In other cases there is the so called 3.2.2 or 3.2.1 approach, in which students take three subjects in the first year of which statistics can be one, reduce this to two in the second year and in the third year take one or two subjects. The person who comes out as the 3.2.1 or a 3.2.2 statistician has different skills derived from the length of time spent on statistics. Even within these 3.2.1 and 3.2.2 schemes there is the possibility of specializing in the last year because of the number of courses offered and the limited number of papers which can actually be taken. It should be mentioned however that this 3.2.2 or 3.2.1 system does not apply to the majority of the training centres in the region.

13. The question which should be answered here is what can be done at the undergraduate (or ITC) level to promote integration. There are at least two options. The first is to prescribe the same mix of courses (including applied statistics) for all undergraduate students. The course in applied statistics will act as the integrating factor. The second option is to retain the same electives as now but use the project work as the basis for integrating various aspects of theory and practice.

14. With respect to the first option, the French are trying an integrated statistics course. This experiment, known as the Case Study "Baramu", seeks to present in an integrated manner courses in industrial statistics, health, education and labour statistics, agricultural, trade and transport and communications statistics. The case study is now being developed and it is thus too early to assess its usefulness in bridging the gap between different types of statisticians. At the graduate level candidates specializing in specific fields such as sampling theory or design of experiment or stochastic processes become even more limited in their range of interests and the general skills acquired. It is here generally that the gaps between different kinds of statisticians become exaggerated and it is at this level that the best solution to bridge the gap should be evolved.

15. In general for M.Sc. degrees and higher, there should be a core which provides for an appropriate mix of courses in theory and practice in several fields with additional options which should also stress theory and applications. In thesis work, candidates should be encouraged to show the interrelationship between their work and other branches of statistics wherever this is appropriate.

Revision of content

16. What has been said in the preceding paragraphs suggests a thorough revision of the present content of courses. The revised course content should as far as possible balance theory with applications. With respect to applications, there is need to select examples from different fields. For example, a course on stochastic processes should in addition to the theory show the applications of, say, Markov chains to the field of demographic and social statistics in addition to the traditional examples. Singer and Spilerman^{3/} have considered the application of transitional probabilities to the study of social statistics. Similar suggestions for the field of demographic and social statistics are given in the System of Social and Demographic Statistics.^{4/}

17. It is however in the project work that improvements can be significant effected. For the middle and intermediate levels, the project should generally involve survey work. The African Household Survey Capability Programme (AHSCP) could be used as a model and the core questionnaire and modules suitably adapted. Alternatively another type of survey in which the household is not the unit of inquiry could be undertaken. For the African continent, two suitable examples of the latter type of survey are an agricultural and an industrial survey. In either case, for the project work to reflect the new ideas on integration, the theoretical basis for methodologies should be explained and the survey carried out from the planning stage through the data collection and processing stages to analysis, evaluation, publication and dissemination of results.

Teaching approaches

18. In spite of attempts at practical orientation of existing courses at some of the centres this has not yielded the desired results because most of the tutors have mainly a theoretical background without any experience in Government or industry. Thus the new teaching programmes being suggested will in general need a new type of tutor. He not only must have a strong academic background but should also have actual experience of the applications of the theories and concepts in his field of specialization. In addition he must have a working knowledge of the main areas of other fields of statistics and be aware of their interrelationship with his own area of specialization.

^{3/} Singer, B and Spilerman, Seymour. Fitting stochastic models to longitudinal data - some examples in the social sciences proceedings of the 41st session of ISI, New Delhi Bulletin of the International Statistical Institute, 1977.

^{4/} United Nations. Towards a System of Social and Demographic Statistics. United Nations, New York 1975.

19. It is to be noted that many of the distinguished scholars in statistics who have produced significant publications in certain areas have also a good knowledge of other areas. What is being suggested therefore is that a tutor in any of the training centres in the region should not be a narrow specialist but when he has specialized, he should retain an interest in developments in other areas of statistics, especially as these may have a bearing on the methods and content of his teaching.

20. One way of acquiring the necessary practical experience is through consulting and collaboration with government or quasi-government statistical offices as well as similar units in industries. Another way is through exposure to non-university institutions for short periods. In a number of developed countries, it is easy to implement arrangements for the exchange of staff between university and non-university institutions. This approach needs to be examined seriously in this region.

21. No stereotype form of training of such a tutor is being prescribed. It would be useful, however, if for graduate courses up to the Ph.D. such tutors should cover a reasonable selection of courses before selecting their specific area of specialization. There is need to develop the region's concept of the training of trainers. In this context, the use of institutions like the International Statistical Programs Centre (ISPC), The United States Bureau of Census and the Munich Centre for Advanced Statistical Training to supplement the knowledge of university tutors should be encouraged.

Relationship of training to work done

22. In the preceding sections, suggestions have been made for integrating statistics at the training stage. For this integration to be meaningful and useful, there is need for the parallel integration of statistics at the workshop level (i.e. in national statistical offices and in industries). This objective may not always be possible, given that some of these industries may have only a narrow statistical focus. For example, the raison d'être for a statistical unit in a brewery may be for quality control checks to be carried out under its guidance. In such a situation, the work is rather limited in scope and the statistician may only be a quality controller without having any working knowledge of other areas of statistics.

23. However for large statistical organizations it is always possible to achieve some measure of integration. In this context, the training centres can still play a useful role by organizing workshops and seminars for practising statisticians which would be aimed at improving their knowledge of the state of the work and at the same time introducing them to relevant recent developments in the fields of statistics.

Conclusion

24. A review has been given in this paper of some of the options available to statistical training centres in the region to play a useful role in the attempt to achieve integration of statistics. As stated in the introductory part of the paper, an ISI committee has examined the whole question of integration. It has recommended inter alia that the ISI Committee on Training and Education should review curricula in statistics with a view toward promoting a core educational programme which will improve the specialized branches of statistics. The proposals made in this paper are in line with this recommendation.

25. What has first to be done is the development of the appropriate core educational programme. The ISI Committee on Training and Education through its Task Forces will no doubt tackle the issue at the global level. It is necessary for STPA to deal with it in the African context. A first step has already been taken in the preparation of a draft guide syllabus for certificate and diploma level courses. The guide syllabuses will have to be reviewed by each centre to ensure that they conform to the spirit of integration. A similar exercise will have to be undertaken for professional training courses. In the latter case, a team of consultants (rather than a consultant) may have to visit a sample of the relevant training institutions.

26. The training centres should also bear in mind that the first degree in statistics or ITS is not enough to qualify a person to be a practical statistician. On-the-job training and short-term courses are needed as a minimum to supplement the first professional qualification in statistics. The training centres can run some of these courses.

27. The proposed Conference on the Teaching of Statistics scheduled to be held in Sheffield, United Kingdom, from 8 to 13 August 1982 should be a useful forum for developing further some of the proposals made in this paper.