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MAIN RESEARCH PROBLEMS IN THE TRAINING OF RESEARCHERS

In this last chapter I will try to summarise the main arguments made in the preceding chapters and the points raised during the Tokyo IASE Round Table Conference debates. During a very productive week at the Institute of Statistical Mathematics, we discussed the issues and problems concerning the Training of Researchers in the Use of Statistics. As suggested by Jolliffe, this is an extensive topic that involves consideration of statistics itself, the interaction between statisticians and researchers, and even the training of statisticians.

My aim in writing this summary is to provide the reader with the view that emerged from our joint reflections about this complex issue and its many facets. The conclusions below are organised around the research questions initially set out in the Discussion Document, which is reproduced in the first chapter of the book, so that the extent to which those questions were taken into account in the different contributions can be more easily perceived.

All the authors highlighted the relevance of improving researchers' statistical training and of making statisticians better acquainted with other research fields for ensuring an optimal communication between statisticians and researchers. However, it was also made clear from the arguments throughout the book that there are no easy or definitive answers to the questions raised.

In addition to the complexity of the topic, little research has been done until now on the teaching of statistics to postgraduates and on the difficulties of learning advanced statistical topics. Even when some of the papers present examples of useful research and innovative teaching experiences, the Conference participants felt that there is an urgent need to increase research in this area.

This chapter then presents not a list of final agreed solutions to the problems of training of researchers, but our view about the main areas in which further research on this field is needed. Some recommendations about ways in which the teaching of statistics might contribute to increasing statistical knowledge among researchers and to better use of statistics in experimental research are also made.

1. SPECIFIC STATISTICAL COMPETENCIES IN THE TRAINING OF RESEARCHERS

Few researchers can do their work effectively today without reference to empirical information and statistics provides a set of tools to manage, organise, describe and interpret this information. As suggested by Miura, due to a rapid progress in information and computer technologies and to the widespread use of friendly computer software, the use of statistical methods for data analysis has become common in research work in fields different from statistics and in practical work in industry and government.

In a wide study of research literature in the biological and health sciences, Harraway et al. classified the statistical methods used in 16 high impact journals during a period of two years. This study, some previous similar studies in education (Elmore, & Woehlke, 1988, 1998) and veterinary journals (Hammer & Buffington, 1994), the analysis of doctoral theses in education by Godino et al., as well as the deep analysis by Blumberg reflect the tremendous variety of both elementary and complex statistical methods that researchers in different areas are using today to carry out their investigations.

This number of useful statistical methods and the quick pace of change and development in statistics mean that researchers' statistical knowledge is insufficient for them to be independent. Consequently, it was emphasised in different papers that it is unrealistic to expect researchers to be their own statisticians and solve all their data analysis problems by themselves. This was also perceived by the researchers themselves, according to the results of the surveys carried out by some participants in the Conference. As argued by Phillips, it is not necessary for particular researchers or departments to do everything by themselves. It is more important that they make use of the diverse and rich resources which exist in their institutions, including statistics consultancy. Chadjipadelis suggests that it is not clear if we should teach statistics to researchers or if it is better to make them understand that they need a statistician as a help, a colleague or even as a leader.

We discussed the main abilities to be emphasised in the training of researchers and there was an agreement that it is important for them to understand the basic ideas in survey and experimental design and data collection. Researchers should be able to read, interpret, communicate and defend arguments based on statistical information. They should develop understanding of assumptions behind statistical methods and use meaningful statistics language. Schuyten also pointed out the need to take into account the interrelationships between research methodology and statistics in the training of researchers.

In Jolliffe's words, training in statistics is a continuing process that comes partly through experience and thus requires a long time. Successful courses will encourage a critical attitude towards data and the results of statistical analyses will allow researchers to experience the variability and accept uncertainty, and increase their interest in statistics. The importance of obtaining good quality data and of exploiting data sets fully should be stressed.

An important part of any training is to draw attention to areas that have not been covered, so that researchers will realise when they need to consult with statisticians. Recommendations were made that short continuing education courses focussed in specific topics are essential for the trained researchers as a means to prevent them making some well known and serious errors; and also that it is convenient to offer these courses in connection with meetings of scientific societies.

2. PARTICULAR NEEDS AND PROBLEMS IN THE STATISTICAL TRAINING OF RESEARCHERS IN SPECIFIC FIELDS

A field where the use of statistics has a long tradition and is now well established is agriculture. Saville describes a number of workshops to fill the training needs of these researchers, based on his long experience of consulting and teaching in an agricultural research institute.

Harraway and his colleagues complement their study of research journals with the description of some case studies and a survey given to researchers and postgraduate students in five different departments. It is apparent from the paper that a great deal of statistics is used by researchers in the biological and medical sciences, although the specific techniques used vary to some extent between and within disciplines. Given the time constraints, they suggested that generic courses should be focused on basic statistics and advanced techniques should be offered only when required by different areas.

While the previous papers focused on statistical techniques and concepts, Bishop and Talbot argue that researchers do not fully grasp the essence of statistical thinking and its ways of reasoning and, there is therefore a need to provide training in statistical strategic skills.

They describe a web-based project to develop statistical thinking directed to researchers in the biological sciences, which is based on the cyclic model by Wild and Pfannkuch (1999), who propose five components: Problem-Plan-Data- Analysis and Conclusions. Even though this particular facility was designed for the biological sciences, the didactical problem of developing statistical thinking in researchers is applicable in general to researchers in different sciences.

In the context of training special education and regular education teachers, Blumberg analyses the usefulness and requirements if training in a number of statistical topics. In his discussion, Brian Phillips argues that not only the teachers, but other professionals such as doctors, social workers, etc. are continually collecting and analysing data on people's behaviours and Blumberg's analysis is valid for them too. Glencross and Mji mention as relevant for the training of researchers in social sciences many of the topics analysed by Blumberg and also describe their workshops in such advanced topics as principal component analysis, correspondence analysis and other multivariate methods.

They recognise that there are problems in presenting the workshops, including the researchers' lack of computer literacy and little formal knowledge of basic statistics and mathematics. However, there was an agreement among participants that a minimum, intuitive knowledge of statistical tools should be provided for researchers if we want them to be able to critically read and interpret research literature in their fields.

3. MAIN LEARNING PROBLEMS, MISCONCEPTIONS AND ERRORS CONCERNING PARTICULAR ADVANCED STATISTICAL CONCEPTS

In the second part of the book we are including a set of papers that specifically dealt with the analysis of the main reasons why training in particular statistical topics is needed. Topics cover association (Estepa & Sánchez-Cobo), categorical data analysis (Svensson), stochastic processes (Wang), quality control (Hirotsu), statistical models (McLean) and Bayesian statistics (Iversen). Other papers in the book analyse the teaching and learning of experimental design and linear models (Saville), statistical thinking (Bishop & Talbot) and multivariate analysis (Crivisqui et al.) or refer to the increasing use of complex methods. A main conclusion from these papers is that statistics is misunderstood and misused by researchers, not only as regards advanced methods such as stochastic processes or multivariate analysis, but also in relation to very basic concepts.

In research carried out with undergraduates, Estepa and Sánchez-Cobo systematically describe errors and misconceptions in a number of concepts related to the idea of association, including functional and random dependence, covariance, correlation and regression. They also summarise other previous research that points to misinterpretation of contingency tables, confusion between correlation and causation, and the effect of previous theories on the interpretation of association (see, for example Beyth- Marom, 1982, for a survey of psychological research on the interpretation of association).

As remarked by Mukherjee in his reaction, it is pretty difficult to provide adequate guidance to people involved in training researchers in this topic. He proposes a number of practical suggestions, such as systematic introduction of themes, stress of real-life situations, starting with data sets and knowledge of the background research. Aliaga also suggests more use of technology and that teaching should move from passive to active and should emphasise statistical thinking. Since previous research (Batanero, Estepa, & Godino, 1997; Morris, 1997; Truran, 1997; Batanero, Godino, & Estepa, 1998) shows that some of these misconceptions are resistant after instruction based on use of computers, and students' active work with real data, we deduce that much more research to evaluate and improve the effectiveness of such approaches is still needed.

Hand (1996) argued that little consideration is given to the measurement level of the data, even when this condition affects the type of applicable statistical analysis. In her paper, Svensson indicates that this is very common when assessing qualitative variables, such as feelings, attitudes, preferences, etc. Since categorical responses are often transformed into numerical scores, there is a temptation to treat such data as numerical values. A problem is that the teaching of statistics is focussed on methods appropriate for quantitative data and, therefore, even well educated researchers might be unaware of the fact that there are statistical methods suitable for ordinal or qualitative data.

Hirotsu and Wang present detailed analyses of the content of courses dealing with quality control and stochastic processes. These analyses again indicate that teaching such topics is not easy at all. In the particular case of stochastic processes a main difficulty is that very advanced mathematical techniques are needed. Additionally, some results in probability and stochastic processes are counter intuitive and researchers can be frustrated in their attempts to understand the same.

However, Wang argues that computer capabilities of simulation and visualisation of abstract ideas and stochastic phenomena might be used to help overcome these difficulties. Conditional probability and the translation of problems from verbal statement to probability formulae are also problematic. As suggested by the author there is scarce didactic material dealing with stochastic processes, in spite of the abundance of formal books on the same, and here is another clear need to continue research on the training of researchers.

Difficulties in understanding statistics do not involve only particular concepts or methods. More importantly researchers do not sufficiently appreciate the role of statistics in the research process and do not realise the series of steps going from theoretical constructs to raw data.

As is remarked by McLean and Iversen, our construction of the world comes from the combination of previous theoretical frameworks, data, statistical analyses and the interpretation of the same. Models are important in the theoretical development of statistics, and modelling takes place at all levels of statistical analysis, although models appear very little in elementary statistical courses. This is perhaps the reason why researchers do not always discriminate between models and data, and do not see models as simplifications of systems.

In McLean's opinion, this can explain the controversy about the nature and role of statistical testing in scientific research (Morrison & Henkel, 1970; Harlow, Mulaik & Steiger, 1997). This discussion was also summarised in Batanero (2000), where I also argue that people confuse not just theoretical hypotheses and data, but they also mix and confuse the different levels of hypotheses in a research study that includes scientific (theoretical), experimental, research and statistical hypotheses.

It is important to make researchers conscious of these different levels of abstraction and also make them understand that finding the perfect model can be less important than finding a simple model that serves to make predictions that are consistent with observations. Researchers should understand that statistical analysis cannot prove that one model is better than another and that statistics cannot be applied in a mechanical way. A lot of personal judgement is needed on the part of the researchers, including the definition of variables and categories, the definition of the model concerned, selection and size of the sample and, of course, the significance level.

In the context of Bayesian statistics, Iversen presents a simple example to show students how different analysis of the same data can lead to very different results. Today, when computers make it easy to perform statistical analysis, people very often carry out complicated calculations, without understanding why they are needed or if they are needed at all, and without thinking about possible alternative methods of analysis.

We use inferential statistics in a non critical way, without reflecting that there are different views about inference and different meanings for the word probability. Moreover, students assign subjective meaning to concepts in classical inference, such as confidence coefficient or significance level. In Iversen's view Bayesian inference is closer to students' intuitions and brings the model and the data closer. There is however an inertia to teach Bayesian statistics or to apply Bayesian statistics, even in situations where a priori information is available and this results in a lack of feedback for decision making from statistical analyses.

4. DESIGN/EVALUATION OF COURSES FOR TRAINING RESEARCHERS

Ottaviani suggests that similar problems are mentioned in several papers, no matter if the situation described happens in a developed or a developing country. The different type of solutions described by the authors also show the importance of the comprehension and attention which must be given to the local situations, the necessity of enhancing statistics, and the intelligent use of local human resources, tools and equipment.

The problems in the training of researchers are increased by the different ways in which the initial statistical training takes place. While the majority of researchers get their training in traditional courses, in some cases statistics is taught by people with no specific training in statistics, who might contribute to the spreading of all the misconceptions and misuses described. In other cases researchers get their training in statistics by referring to books or by using statistical packages, without any formal training in the topic. In Iversen's words, statisticians have completely lost control of their field.

Some authors present their experiences in training researchers in statistics. For example, Saville describes in detail the contents of workshops that have been successfully run with the aim of introducing basic statistical ideas to agricultural researchers. He gives a list of essential ingredients for these courses: starting from the

beginning, going slow, providing hands-on work with data sets in the area, encouraging participation and interaction, experiencing variability, learning to cope with uncertainty, building confidence and interest in statistics.

A number of authors also agree that the methodology for such courses should be based on encouraging participation and interaction, and working with data sets in their research's areas. In some cases courses focus on the complete process of research as a coherent integrated activity going from the formulation of a research problem to writing the research report (Glencross, & Mji). Examples of innovative solutions include Internet courses (Bishop, Stangl, Lee, and Shia); courses on critical appraisal of statistical analysis in research bibliography (Bangdiwala), in writing research reports, project proposals or papers, or in supervising research (Glencross, & Mji).

The majority of papers describe teaching in a University setting. However, in countries like Japan there are no departments of statistics at Universities. To solve the problem of covering the statistics training needed in order to perform total quality management, Japanese companies have organised their own training systems that involve all the staff and departments. Hirotsu described some courses as well as the role played by the Japanese Standards Association and Japanese Union of Scientists and Engineers to complement these training needs in Japan.

The goals of the INCLEN program (Bangdiwala & Muñoz), were to develop units of excellence in clinical epidemiology research at the participating medical schools in the developing countries. That program not only provided training of physicians in statistics and training of statisticians in clinical epidemiology methods, but also gave participants time for conducting research activities, and provided them with other support required when returning to their countries. Currently, INCLEN has trained over 500 health professionals world-wide and has created Clinical Epidemiology Research and Training Centres (CERTC) in such diverse countries as Brazil, Chile, Colombia, Thailand, the Philippines, and India.

PRESTA (Crivisqui et al) is another successful international training programme in applied statistics for teachers and researchers in South American universities, sponsored by the European Union. The seminars organised in its first quinquennium were attended by 2,500 researchers and lecturers from about 300 universities. A co-operative strategy in five stages was devised to create an autonomous local system for statistical training. This strategy included the organisation of regional seminars to train future trainers in the region, the progressive incorporation of those trainers in the teaching tasks, providing bibliographical and software resources, developing centres for distance education and promoting joint local research projects with the support from European laboratories.

The Universidad Nacional de Colombia (UNC) is the only institution of higher education in Colombia which offers undergraduate and graduate programs (Specialisation, Master and Ph.D.) in statistics. Ospina describes and analyses these programs, including the results of an international evaluation of the Master's programme made by a committee of the American Statistical Association two years ago.

Finally Wei analyses the training needs in statistics produced by the change that China is going through in transferring from planned economy to market economy. China had until recently a huge planning system where local statistical data was collected and analysed, by different levels of statistical offices. Right now, the system employs over 2 million people, and the training of official statisticians is a huge task. In his paper Wei describes the complex statistical training system, types of training programmes, including distance education, and the role played by the Chinese Statistical Society to help in developing this training system.

This last set of papers posed big challenges for statistics education, and, as Ottaviani suggests, they also show how statistics and its teaching are connected with the socio-economic and political situation of a country.

We were glad to know the role played by local associations of statistics education, research resources centres, and international projects to solve these problems in an imaginative way. We hope to be able to see many more similar examples of national and international support to develop research excellence through supporting the training of researchers in statistics and the adequate use of statistics in research in the near future. We agree with Miura that the IASE can play an important role in strengthening international co-operation and promoting research and development in the training of statistics at the different educational levels.

5. THE EFFECTS OF TECHNOLOGY ON THE STATISTICAL TRAINING OF RESEARCHERS

Technology is creating new didactical problems. McDonald describes the experience of Statistics New Zealand in sharing micro data with researchers. As discussed in her paper, statistical agencies and other institutions rely heavily on public trust and good will and this affects their policies of data access and confidentiality. Since these agencies cannot always undertake in-depth analysis of the data they collect, there is an increasing tendency to share some of the data on the request of researchers and this benefits both parties.

It is important that researchers who have access to these facilities carefully consider the data and variables they require to minimise disclosure risk. In some cases using large data sets would imply access to specific software that is unfamiliar to researchers. During their training researchers only deal with data they have collected themselves or with data sets that have being specially prepared for teaching. In this case, data are "error free" and the original file has usually been simplified.

The researcher is then not conscious of the full complexity of data and does not realise all the processes that are applied after the data has been collected, such as coding, recording, editing and transforming the variables. There is also a perception that the data have a high degree of precision since they were collected by an official agency, without being conscious of the limitations due to the sample design and instrument used to collect the data. McDonald recommends that courses directed to these researchers should include all the points above as well as discussion of the advantages and disadvantages of using large complex data sets.

As discussed by Shimada with an example, an important danger is misusing statistical software or using software without a careful evaluation of the same. Since computers and software are widely available, the question about whether a particular analysis is worth doing does not even arise. As discussed by Lee, access to computers increases the requirement for a statistical understanding among scientists and professionals in order to choose the appropriate statistical method and to interpret the results obtained by the computer. The possibilities given by interactive software, enabling each step to be studied before the next is taken, should not be under-rated. Researchers without a deep statistical knowledge just use the standard options since they do not possess a full knowledge of the software possibilities and how they relate to the different types and conditions of statistical analysis.

When the analysis is carried out by a statistician there is also difficulty in communicating the results that arise from complex statistical techniques to users because they do not always have the theoretical background to understand what has been done.

Technology is also offering didactical possibilities. While researchers perceive their data analysis problems to be too specific to be discussed in a general course or seminar, in the experience of Bishop and Talbot, the Internet made it possible for each student or researcher to concentrate on the particular concept or the particular research stage he/she needs to study more in depth. In Korea the government is encouraging partnership among universities and the private sector to share existing resources to provide instruction to students and adults supported by new technologies. The idea of "electronic school" and the changes and possibilities of this new type of education is also discussed by Shia.

Stangl analyses the didactical features of the Internet, which provides interactivity, can adapt to the pace of changes, is accessible to a wide number of students and is flexible. She suggests that it is not aimed to replace the lecturer or the textbook, but to complement both and can make education more individualised. Via discussion groups students and lecturers can interact and come together across great distances and thus facilitate continuing education.

A good design of a course, however, requires a series of decisions as regards the software, slides, scripts, testing, implementation and updating. It also requires a complex production process that will ensure that the project will meet the user's needs and is sustainable in the long run. All of this adds new research points as well as new training needs for the course developers, lecturers and students.

Finally, as stated by Galmacci, Internet is changing both the way we work in statistics and the way we teach statistics. The large amount of data available from the Internet facilitates teaching based on working with real data and with real projects. It also provides a variety of resources to help researchers in developing their research and in particular to do the elementary or routine data analysis. Faster communication, electronic journals, discussion lists, electronic books and expert systems incorporated in statistical software are contributing to the diffusion and democratisation of statistical knowledge, and at the same time are giving students more responsibility in their own learning.

As stated by Araya, the Internet has brought about a tremendous effort in the education sector. However the traditional ways of keeping close contact between teachers and students and doing some graphics and computation by hand or calculators is also important for beginners. The quick revolution of the past few years has shown the advantage of this new technology; however it is a task for researchers to explore and to exploit these opportunities to improve the teaching and the use of statistics.

6. ERRORS AND ATTITUDES IN THE USE OF STATISTICS BY RESEARCHERS

Some chapters refer to the researchers' errors in using and interpreting statistics methods. Svensson, Lee, and Harraway et al. provide references in various reviews of medical journals, where the poor quality of methodology and statistics in research journals in medicine is highlighted. In analyses of a small number of doctoral dissertations in mathematics education Godino et al. found a variety of incorrect uses and interpretations of statistical methods and results, some of which had been

previously described in research literature, particularly in mathematics education (White, 1980). Their results suggest the difficulty that researchers who have not specialised in statistics find in carrying out their own data analysis and the consequences that this might imply for the quality of their research work.

The incorrect use of statistics is also reflected in the current controversies around statistical tests mentioned before. Several organisations have recently established special committees to study the use of statistics in experimental research. For example, the American Psychological Association (APA), in a 1994 publication manual, noted that significance testing does not reflect the importance or magnitude of an effect, and encouraged researchers to provide effect-size information (American Psychological Association, 1994, p. 18). Subsequently, the Task Force on Statistical Inference established by the APA published an article to initiate discussion in the field prior to revising the APA publication manual (Wilkinson, 1999).

As regards attitudes, Svensson's surveys of researchers with good basic knowledge of statistics showed that contact with a statistician had a low priority for these researchers, due mainly to a lack of experienced statisticians and the lack of a common language between statisticians and researchers. According to Bangdiwala and Muñoz, statisticians are placed on a pedestal and there is not a true collaboration with researchers, which results in poorly planned, conducted, analysed, interpreted or presented research.

Belli's survey suggests that many researchers are reactive and only consult the statistician after their data have been collected, since they are not conscious of the relevance of experimental control and random sampling. According to Jolliffe, sometimes they have already entered the data in a spreadsheet or have attempted some preliminary analysis. Such researchers often present their results to a statistical consultant hoping that a suitable analysis will rescue a poorly designed study (Bishop, & Talbot).

It is necessary to increase the appreciation of statistical work on the part of researchers. Statisticians are viewed as a necessary evil that must provide significant results and there is not a true collaboration with researchers. Their consultancy work is not always valued as it should be and it is difficult to get institutional funding or get co-authorship on published work where the statistician provided substantial input.

Another important issue is the potential disagreement between members within a research group when introducing new statistical approaches (Svensson). Since they are anxious not to lose comparability with other studies there is a preference for traditional statistical methods. Although the reasons for such inertia might also be found in a lack of knowledge, the survey by Svensson also confirmed potential conflicts between the use of non-standard statistical methods in applied research in terms of acceptance by referees and journals.

7. CONSULTATION AND A TEACHING /LEARNING PROCESS

A good opportunity for training occurs when researchers consult with statisticians. In Jolliffe's opinion, the researcher has to communicate the problem to the statistician, including some ideas of relevant theory from the subject area and the aims of the study. The statistician and the researcher should agree about simplifying assumptions, in case they are needed for the statistical analysis and the statistician can help clarify the questions that the researcher wishes to consider. The statistician, in turn, should be able to communicate the statistics techniques and results in a way which is understandable to

the user and also to the audience of the research report.

Saville describes many different types of consultations and the steps where the statistician may give advice. Through this process researchers will learn about research design and statistical analysis, and also about the type of question they can ask a statistician. Statisticians, in turn, will learn teaching and consultancy skills, and will increase their knowledge of statistics through applying new techniques to challenging problems.

Consultancy practices carried out by students is a didactical device that is planned or used in different countries as a means for both providing practical experience to future statisticians, and creating a culture favourable to the value of statistical consultancy by future researchers. In Belli's survey consultants are conscious of their role in helping to develop researchers quantitative thinking. They have the unique opportunity of teaching clients with their own data and examples. They also perceived that a main educational goal for consultants is to change "reactive" researchers who approach the consultant only when the data have been collected to "proactive or collaborative" researchers, that is, clients who count on the statistician from the very beginning of their research.

Consultancy skills are an important part of the statistician' s training and this is mostly done by exposing students to a range of problems from various disciplines. It was noticed in the surveys by Godino et al. that statistics knowledge is only a part of the training needed and that future statisticians feel they lack abilities for producing written reports, communicating with clients, and managing a consulting session, and they also need the support of expert statisticians while doing consultancy practice. Developing ability in problem formulation was another point suggested in Belli's survey. The relevance of making statisticians better acquainted with other research fields for assuring an optimal communication among statisticians and researchers was also made clear in the discussions by different participants.

Since institutional services of consulting are not currently available in some Universities or countries, it is important to create statistics labs and statistics consultancy services in Universities and research centres, not only to help researchers, but also to contribute to the training of both researchers and statisticians. A very interesting example is the research resource centre described by Glencross & Mji where regular on-going research training and consultancy is provided to researchers and postgraduate students. This includes, project planning, writing of research proposals, collecting and analysing data, and providing information about funding resources. However, as pointed out by Ottaviani, it still seems to be very difficult to create a correct “equilibrium” between teaching and practising statistics.

8. LEARNING FROM RESEARCH LITERATURE

An important opportunity to learn statistics is provided by reading statistics materials included in research papers. Researchers, however do not take advantage of this chance and often ignore the methods section when reading research papers in their own scientific fields. This also suggests that they have difficulties in reading this material and thus they cannot critically evaluate research nor effectively collaborate in a research team (Bangdiwala, & Muñoz).

One cause of this situation is that editors of research journals suggest that description of statistical methods be minimised or just replaced by reference to a statistical book, even if the method is new or scarcely used. However, the description of the statistical analysis, including the assumptions made and limitations of models is as

relevant as a description of the method of data collection and of the way the sample was taken. It is not uncommon to have difficulties in getting papers describing new statistical methods or correcting erroneous statistics, published in research journals. We think that an urgent task for statistics education is to write didactical explanations of new statistical methods available in an understandable way for applied scientists.

Finally, since mistakes and misinterpretations in the use of statistics are frequent in published research, these errors and misuses might be spread when new researchers try to find how statistics was used in a particular research or try to replicate a given research. An important recommendation is that top quality research journals include a statistical review of submitted papers in addition to the traditional scientific review, before accepting a paper for publication.

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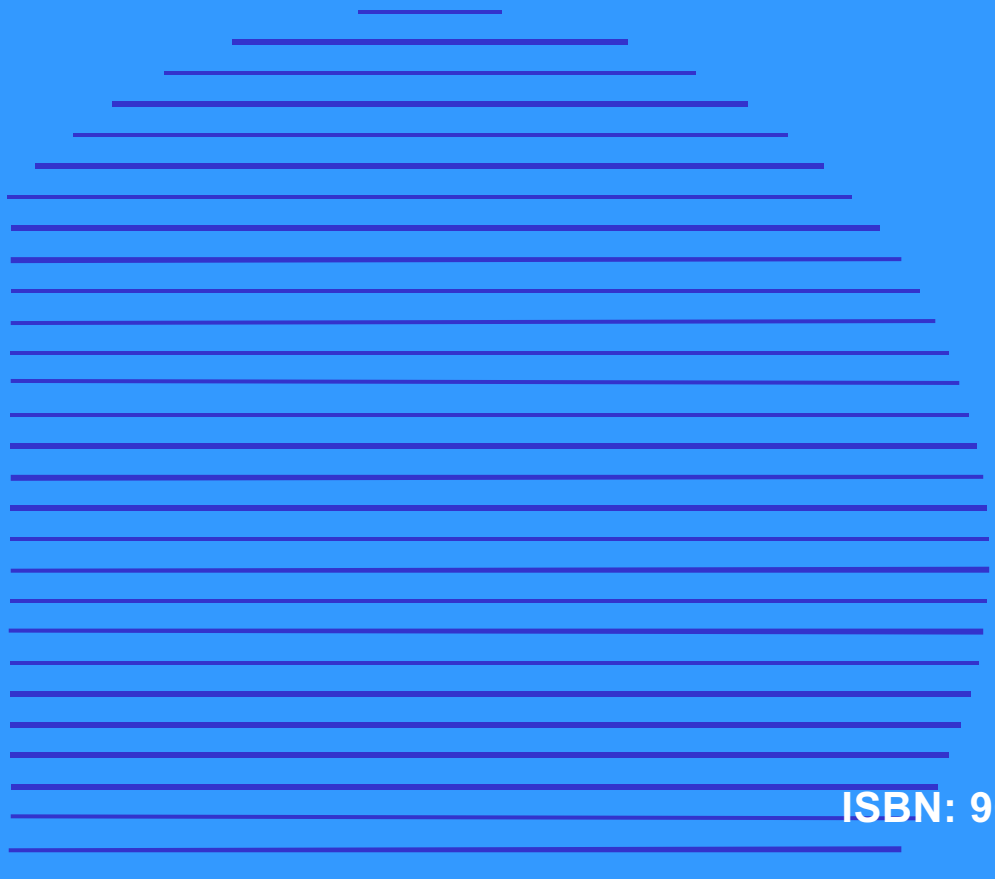
"There is no doubt that Training Researchers in the Use of Statistics is very important to improve the quality of empirical research and to foster technical and economical development. However, since the logic of statistical inference is difficult to grasp, its use and interpretation are not always adequate and have been criticised for nearly 50 years. In this book the reader will find various analysis of the problems related to the training of researchers, and a number of views of ways in which some of these problems might be solved."



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