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STATISTICAL RESEARCH AND CONSULTING IN UNIVERSITIES FROM DEVELOPING COUNTRIES: THE COLOMBIAN CASE

This paper focuses on describing the experience of statistical researchers and consultants of the Department of Mathematics and Statistics, faculty and students, and of researchers who are not statisticians, at the Universidad Nacional de Colombia. An analysis is made of the statistics programs of study including consulting activities, and of three surveys that were designed, distributed and analysed: one for the newly graduated and senior year students concerning their training in research and consulting during their studies; a second one for statistics staff at the department and a third for non-statistician researchers at the University who usually have to deal with statistical methods.

A study is made of the main problems in the formation and training of students as statistical researchers and consultants, as well as the difficulties of the experienced researchers and consultants. Recommendations to improve the actual situation are proposed.

1. INTRODUCTION

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. The undergraduate program started in the second half of the 50's; the specialisation and master programs at the beginning of the 80's and the Ph.D. program will start this year. The undergraduate program has been modified on several occasions through the years in order to keep abreast of scientific and technological advances.

The latest and most important modifications occurred in 1995. The master program was reformed most recently two years ago. An international committee suggested by the ASA (American Statistical Association), made an evaluation of the program for the purpose of obtaining international accreditation.

The main conclusions of this evaluation are mentioned later but they have not been implemented completely. The specialisation program, an equivalent to the Master of Arts at the U.S. universities, has had relative success and has served as a bridge to get in touch with industry and some public and private agencies and institutions. The Ph.D. program is just starting, and therefore, no evaluation should be made of it.

In this paper the curricula of the statistical programs, with the exception of the Ph.D., are examined to determine their main weaknesses. To find out the opinion of the students (newly graduated and senior year statistical students), of the Statistics Department staff and of some non-statistician researchers and consultants of the University, three different surveys were taken and analysed. Through the analysis of the

curricula and these surveys, the main reasons that usually prevent the statistician graduates from being successful in consulting and research were detected. As a consequence, important changes in the structure of the programs, modifications to several subjects' syllabi and a drastic change of the consulting process offered by the department are suggested.

The actual curricula are studied in the first part of the paper. This also includes a description of the statistical demand at the department and how it is satisfied. A second section is devoted to analysing the data provided by the surveys. There is also a section of general conclusions on the limitations of the curricula and a last one giving some recommendations to improve the actual situation.

2. STATISTICS PROGRAMS

2.1. UNDERGRADUATE PROGRAM (COMITÉ PROGRAMAS CURRICULARES DE ESTADÍSTICA, 1999)

The undergraduate program in statistics at the UNC is the only one in Colombia, which has been functioning without interruption since its creation, on 17th February, 1956. The number of graduates has totalled 400 in 40 years. Programs in statistics have started at some other universities but they have failed to survive because of low student population. This has mainly been due to the poor tradition of statistical studies. Before the 80's the high school students did not have a clear idea what statistics programs were about.

The people responsible for the statistical work have been usually trained at the same institutions through seminars and short courses given by experts. A few of them are sent abroad to obtain a more formal education. Eventually, the UNC contributes to this training but this is not the rule.

In contrast to other developing countries, there is not an important association caring for statistical education. In China, for example, according to Wei (2001), there is a National Statistical Education Association, which, among other activities, is in charge of the official statisticians' training. Different from Colombia, they have a well-programmed national statistics officers' training program. Colombia, with a population over 40 million and more than 100 colleges and universities is in need of a strong statistics association and an improved co-ordination among the institutions that have to do with statistics work, whether public or private.

The program at UNC has overcome several crises, for the same reason, but now seems stronger than ever. At the beginning it was a six-semester program (on the technological level). In 1970 a new plan of study of eight semesters was introduced and finally, in 1979, the program became a professional one with a duration of ten semesters.

The curriculum has had major and minor changes in an effort to maintain itself on a par with the scientific and technological advancements. The goals of the program are to form professionals who contribute to the development of statistics as a discipline and who possess abilities and capacities to apply statistical methods to the analysis and solution of problems and to formulate models in technical and scientific areas.

This goal has not been completely fulfilled because opportunities for interaction with scientists and professionals, leading to research and consulting, have not been as

successful as has been desired.

The main reason for that must be that the program has been traditionally dominated by theoretical knowledge. Only during the past years (second half of the nineties), has a Consulting course become part of the curriculum. Furthermore, the office of extension of the department has allowed some of the students to get in touch with real data when they collaborate with the projects under the supervision of faculty members. A description and analysis of the actual program, trying to detect its weaknesses, follows.

Basic phase

The basic phase of study corresponds to the first four semesters of the curriculum and is common with the mathematics program. This phase provides the student with the fundamental elements of the areas of mathematics and statistics, and tries to give a general vision of the profession. The subjects of this cycle are: Foundations of Mathematics, Calculus I, II, and III, Differential Equations, Elementary Geometry, Linear Algebra I, Linear Algebra II, Logic of Programming, Linear Programming, Professional Introduction, General Statistics, Probability and Statistical Inference.

Basic statistics phase

The phase devoted to fundamental knowledge of statistics extends from the fifth to the eighth semester and consists of nine subjects that constitute the culmination of the disciplinary nucleus in the professional formation of the students. The acquired formation establishes the difference from other disciplines and brings the student to understand the different theoretic and practical orientations in statistics. The following subjects are included in this phase: Statistical Theory, Sampling Theory, Statistical Methodology, Statistical Computing, Linear Models, Multivariate Analysis, Experimental Design I, Non-parametric Statistics and Time Series I.

Statistics specialisation phase

This phase constitutes the flexible part of the curriculum. It usually starts in the sixth or seventh semester and goes to the ninth. The student must choose an area of specialisation and take six subjects corresponding to that area. The objective is to study the theory and statistical methods related to the area in depth. The areas are Data Analysis, Mathematical Statistics, Time Series, Experimental Statistics and Statistics in Populations.

Other requirements

In addition to all the subjects above described, the student must take and approve a comprehensive exam of scientific texts in a foreign language (English, French or German), before the fifth semester. Two humanities courses and two more subjects, called “context courses”, related to the analysis of topics of general academic or national interest are also required.

The Consulting course is given during the last semester and it is expected that, during this course, the student will analyse real data from problems where statistical methodology and theory are needed. As a culmination of his studies the student may choose between writing a monograph or doing a semester of practicals with some interested industry or institution.

Discussion

According to the document prepared by the Statistics Curriculum Committee the new statistical demands show the existence of an important difference between what is expected from the statistician and what is given by his university formation. These demands are a product of the global human evolution, especially in relation to technological development, socio-economic evolution and the new politics of international openness and globalisation.

The technological evolution implies a new conception of information systems, a change in the way data are produced and collected and also a change in their treatment. It is important to know and use modern information techniques, to be able to analyse and interpret the results from statistical analysis more than simply to use the tools, and to formalise the complete process in experimental research, among others.

Opinion and studies from specialists help in making decisions about an essential modification of the program of study. Jammalamadeka (1994) holds that there must be equilibrium among mathematics, statistics, computation and areas of application (biology, economy, medicine, etc.).

This means less reliance on mathematics (some of the mathematics courses could be modified and a couple of them suppressed), more and better use of computers (which also demands the purchase of more and better computers) and more interaction with substantive disciplines. The program itself apparently fulfils the needs for statisticians in industry. However, there are some applied areas that have not been considered. Among them, psychometrics and biometrics seem to be the most important. Kettenring (1995) suggests that:

> *"Basic building blocks of any program should continue to be well-rounded statistical knowledge including subjects such as data analysis, statistical computing, sampling, linear models, experimental design, time series, multivariate analysis, and so forth"* (p. 3).

The program covers all of these topics as basic courses with the exception of Data Analysis, which is a specialised subject. The problem is not the number of courses of the program because they are numerous and cover the main areas, possibly more extensive than most of the North American and European statistical programs. According to Scheaffer (1991), the important issue is that the application of statistics courses to real data has not been sufficient.

> *"Engaging in real research provides students with a feeling of ownership of the data and the excitement of discovery that is absent from textbook exercises." "The best way to know statistics is not only to teach but to be a consultant in it"(*Brook, 1994, p. 257).

The actual contact with real data often occurs during the last two semesters, mainly through the Consulting office. Schuenemayer (1991) also refers to this situation when he states that, first, statistics refers to data and, second, every statistician is a consultant. Therefore, students' training for consulting must start earlier in the program.

Finally, in an article presented at the 1993 Joint Statistical Meetings in San Francisco, Garfield (1995) mentions some important aspects needed in statistical education. They are teamwork and collaboration, communication skills (oral and written), solution of real problems with real data, internships and real-world experiences in analysing data. All the recommendations should be given keeping in mind what lies ahead. Moore (1997) warns about the changes due to the advance of technology:

> *"The quantization of society is in its turn driven by the implacable advance of technology. Changes in computing, communications, and multimedia come so rapidly that comments in a printed journal are out of data before publication. Technology changes how we teach as well as creating demands for teaching new content. My thesis is that the most effective learning takes place when content (what we want students to learn), pedagogy (what we do to help them learn), and technology reinforce each other in a balanced manner.*" (Moore, 1997, p. 124)

Essentially reforms of the curriculum are important but more than that there must be a commitment among staff members concerning the changes needed in the teaching and the contents of the different subjects.

To summarise, the program must be substantially modified in the following aspects: A reform of some of the first mathematics courses is needed, among them, Elementary Geometry, Professional Introduction, Linear Algebra (I and II) and Calculus (including Differential Equations). The main geometric concepts can be included in one of the Linear Algebra courses.

The four calculus courses can be reduced to three including the main concepts of differentiation, integration, series and differential equations. The number of courses should be diminished, but the level should remain the same.

> "*It is nonetheless true that statistics makes heavy and essential use of mathematics, that advanced training in statistics requires considerable exposure to mathematics, and that elaborate mathematical theories underlie some part of statistics."* (Moore, 1997, p. 125).

The Professional Introduction course should be moved to a more advanced semester, maybe the fifth or the sixth, when the students can take better advantage of it. Garfield and Gal (1999) give some important challenges for statistics teachers (or professors). Some of these challenges are equally valid for the statistics students and should be taken into account as part of the Professional Introduction course in case the curriculum is modified. These are:

1. Understand the purpose and logic of statistical investigations;
2. Understand the process of statistical investigations;
3. Master important procedural skills;
4. Develop interpretative skills and statistical literacy;
5. Develop ability to communicate statistically.

There must be an emphasis on communication skills. This could be attained by demanding well-written reports from the students in those courses that involve home assignments or through a specific course. What Glencross and Mji (2001) say about the need for social researchers to learn how to write research reports, is also valid for statistics students because they will have to face this issue very often once they finish their studies. While statistical and methodological knowledge is certainly important, it is not effective if the consultant cannot adequately communicate it or cannot manage a consulting session properly" (Belli, 2001).

Better education and training in computational statistics and information systems in general is required. Familiarity with computers is an essential requirement for each statistician. One of the most important challenges in the actual world has to do with the

handling of large amounts of data and this is possible only with good computational training and knowledge.

Moore (1997) is right when he states that heavy use of computing technology is essential for realistic learning of practical statistics. Additional benefits are also obtained. Advances in computing have made areas like re-sampling and non-parametric regression of practical relevance and have opened up many application areas for research in data analysis and statistics (Cameron, 1997).

One or two more courses on information systems or database handling are necessary. The main problem, also shared by Chinese programs (Wei, 2001), to fulfil this requirement is that still some of the main applied courses are taught separately from computer courses.

The specialisation cycle has not given the expected results. The general feeling is that a more integral formation in basic statistics areas is preferable to an early specialisation in one of them that could be obtained during graduate studies.

The specialisation in one particular area for the students, often with no real experience at all, prevents them from taking some other courses in different statistical areas that would allow them to qualify better in the statistical job market. Besides, the reduced number of teachers sometimes makes it difficult to offer some of the specialised courses, which are demanded by the students. An increase in contact with the external world is urgent:

> *"Statistical training should be truly holistic because that is the way statisticians are expected to operate in the real world..... To reach this state in university statistics education, closer working ties with industry would be worthwhile."* (Kettenring, 1995, p. 3).

> "*It is recommended that university courses on quantitative research include a section on the use of official statistics and the pros and cons of using large micro data sets, e.g. using hierarchical data sets, dealing with missing values and non-response, with imputed and edited data, appropriate use of weights, analysis of complex design, and managing disclosure control*" (McDonald, 2001, p. 127).

> "*…with the large amount of data available via the Internet, there can be no excuse for not getting students to work on real data*" (Jolliffe, 2001, p. 357).

The university has a shortage in providing these tools, not fulfilling the challenge of both, globalisation and technology. The seminar, the consulting course and the monograph must be reoriented to get all the benefit that can be obtained from them. A recent graduate should be capable of participating in interdisciplinary groups.

It seems urgent to create what is called '*Statistics* Lab' in many universities in other countries where several members of the Statistics Department could share the whole responsibility of the consulting process. The problem that newly graduated statisticians have when they leave the university and have to cope with the reality has been already mentioned:

> *"The shock for newly graduated statisticians is to find that many of the practical techniques used on a weekly basis seem to start near to where their university courses ended. Moreover the customer appears so knowledgeable. The trust can be built through the teamwork.*" (Pike, 1994, p. 358).

As Godino et al. (2001) recommends consultancy courses should have an essentially practical orientation and be based on the philosophy of workshops and seminars, with the support of a network of centres where practices would be carried out. Smith (1994) considers that a consulting course must be based on three items:

(1) Applied statistical projects;
(2) Rreport writing; and
(3) Classes given by experienced students.

The first one has been the raw material while the second one has been neglected and only during the last semester was considered seriously. No class by experienced students has been considered but some members of the staff have been eventually invited to give some lectures. It is important for the three items to be satisfied in the regular course.

A semester devoted to practical training must be guaranteed through regular agreements with industry and private and public institutions. This requirement, an alternative to the monograph has failed in the past and is being implemented once again. This seems to be a difficult task due, in part, to the poor statistical knowledge that people in charge of industries, factories and institutes have. Statistical work has been usually done by economists, business administrators or accountants, who often do a poor job. The program has come up short in this sense. As Scheaffer (1997) recommends, when talking about new pedagogy and content in statistics education the learning of statistics must move from passive to active.

Students' consulting activities

A statistician must be able to effectively communicate with researchers and practitioners and be conversant in their functional areas. Consulting skills should therefore be an important aspect of statistical training (Belli, 2001). In Colombia, like in Spain, there is neither a culture that favours statistical consultancy, nor a deserved scientific or economical recognition of this work (Godino et al., 2001).

The Statistics Department has a consulting service offered to the University community through their students. The two main reasons to keep the consulting service are the same presented by Belli (2001) in her survey to 106 USA departments, that is, to provide statistical assistance to faculty and to serve as a training ground for consulting students.

The service charges no fees and is usually provided to students from other disciplines, especially for theses or final monographs. In a few cases researchers from other departments also ask for assistance of this kind. The consulting activities are part of the undergraduate program (registered as a consulting course to be taken in the ninth semester) and are required by all students.

Every student should stay in the consulting office during a two-hour period twice a week. Those interested in the service must register in advance for a 20 minutes session each time. They must take with them all the pertinent documentation, including the research proposal, the most important references on the theme, the measurement instruments, and, eventually, the data collected. The initial discussion is focused on the description of the problem and the methodological aspects of the task, especially on the objectives.

As a general rule, there is no discussion of the statistical analysis strategies during the first session. These will be discussed when the problem has been sufficiently clarified. There are as many sessions as required. In some cases methodology and data collection are followed closely; in others discussion of related concepts seems to be more important in order to adequately orient the statistical task. An experienced member of the department staff, responsible for the course, supervises the process.

As part of the training, every week there is a session among the members of the consulting group where the problems and solutions for the different situations are discussed. If there are difficulties with some specific areas, consultation with specialised teachers in the respective topics is proposed.

When the student gets the data collected, he/she analyses it and writes an initial report for the customers. This report must contain a reading of the obtained data and some recommendations on the tables and graphs presentations that the customers must complete. Very often the data have already been collected using instruments of dubious quality or inadequately applied and there may also be doubt cast on the observation methodology (experimental or from sample). From the students' point of view the experience is surprising. Their first impression is that they have not been prepared to face this kind of problem.

Experimental design and sampling are the main areas where people consult. This means that most of the student activities as consultants are referred to specific problems on estimation and hypothesis testing.

The absence of group work during the program of studies, with a few exceptions as well as the limited interdisciplinary work, constitutes a major weakness of the curriculum. This prevents the students from participating as colleagues from the beginning of the projects, sharing responsibilities in some of the research phases.

2.2. GRADUATE PROGRAMS

2.2.1. SPECIALISATION

This program has been designed for professionals in different areas involved mainly with the implementation of statistical methods. It is a three-semester program for full-time students, which has run for almost two decades. However, since most of the students have to work, the classes have been offered at the weekend making it into a part-time program, which lasts five semesters instead of three.

The program has been taken to some provincial universities with good results, especially for professionals with a major in mathematics. During the last few years participation of students from other disciplines has increased, a situation that has helped the statistics program because it has become well known to many people and institutions, producing a larger number of applications.

North American or European universities do not offer this type of program. However, in the United States a similar graduate program called Master of Arts in which the candidate does not have to write a thesis but rather a monograph is offered. The main difference is that at the UNC the courses are not the same as those offered in the masters program, whereas in the United States they usually are. The curriculum includes both basic and special subjects as well as a seminar, whose description follows:

Basic phase

The basic subjects provide the students with a general formation in statistics and mathematics, especially those with a deficient background in these areas. The subjects are Basic Probability Theory, Linear Algebra, Basic Mathematics, Statistical Methods and Regression Methods.

Special phase

The special subjects are related to specific topics in a given statistical area. Usually the students choose those most related to their work experience. The subjects are Econometrics, Sampling, Qualitative Data Analysis, Non-Parametric Statistics, Experimental Design, Time Series, Multivariate Analysis, Data Analysis and Special Topics in Statistics.

Seminar and other requirements

The Seminar is a course designed to present and discuss several themes and experiences at different levels (applied, theoretic or educational) related to the statistical interests of the students. The idea is to familiarise the students with the application of statistical methods to specific situations.

Besides the above courses, the students must take and approve a comprehensive test in a foreign language (English, German or French) before the first year. As a final requirement they must elaborate, under a professor's guide, and defend, a monograph, generally related to their jobs.

Discussion

The program in general is working well. However there are some important aspects missing. The first one has to do with the relatively poor emphasis in computation techniques, especially large data base handling. This is not a difficult problem to solve. Nevertheless, the statistics professor should be very careful when teaching these topics because computer programs in some situations give the false sense that the statistical professional assistance is not needed (Gowler and Diggle, 1987). Shimada (2001) has already pointed it out when he says:

> "*…there are many statistical packages available that make it easy to perform stochastic procedures. Therefore, today's students and researchers may think they can handle their data processing needs, and obtain stochastic results simply by clicking a PC button. However without being aware of it, they can make mistakes and treat their data incorrectly*". (Shimada, 2001, p. 127).

In the same article Shimada presents a real situation where it is very easy to make an important mistake. Jolliffe (2001) also refers to this situation when she suggest that the statistician has to some extent been replaced by the computer, so it is particularly important that, researchers are made aware of the dangers of misusing statistical packages and of the errors inherent in some routines.

Probably this is one of the reasons why an increasing number of people are using these tools. Muller (1989) had already pointed out how statistical computing has started to become a common practice. The second aspect is the lack of consulting. Even though most of the students work in an industry or at a private or public institution, they are not familiar with statistical consulting practice. A course similar to the one in the

undergraduate program should be established.

2.2.2. MASTER OF SCIENCE

The Master of Science (MSc) program is directed to professionals with intermediate knowledge in statistics, probability and mathematics (including linear algebra). It was created officially in October 1979 and has been reformed on various occasions since then.

The most significant is possibly the last reform in 1998. In twenty years less than forty students have been able to get their degree. According to the 1998 reform, the aim of the program is to form statistical researchers able to formulate a statistics problem, to modify or to innovate existing solutions and to use the new results in the analysis and interpretation of the statistical data pertaining to the problem.

The curriculum has been designed to last four semesters for a full-time student. It consists of four basic courses and at least two special ones, and three seminars destined to orientate the students properly in their area of interest.

Basic phase

The basic subjects provide the students with a solid formation in statistics in order to enable them to face a statistics problem with the required academic seriousness. The subjects are Advanced Linear Algebra, Linear Models, Mathematical Statistics and Statistical Methods.

Advanced phase

This phase includes the special subjects, related directly to the specific area to which the student's research problem belongs, as well as the seminars. The candidate must write a thesis referred to his research problem as culmination of the program. The originality of the work is considered to be proof of his ability to research in statistics.

International evaluation

An Accreditation Team appointed by Dr. Kettering, then President of the ASA reviewed this Master program. This Team was formed by: Professor Alicia Carriquiry (Iowa State University), Professor Wayne Fuller (Iowa State University) and Professor Edward George (University of Texas at Austin).

The Committee visited the Department of Mathematics and Statistics of the Universidad Nacional de Colombia (UNC) in August 1998. The Committee found that the Master of Science program meets requirements comparable to those satisfied by programs in countries such as the United States and Canada.

However, the following comments and recommendations were made (Carriquiry, Fuller and George, 1998):

- The Department has an well-educated, diverse faculty, which displays strength in both theoretical and methodological areas. The research component in the Department would be improved if faculty members have the opportunity to obtain advanced degrees abroad.
- The student body, while enthusiastic and competent, could be larger given the number of faculty in the Department. One way to increase the number of graduate students in Statistics is to recruit students from other disciplines. The benefits of a

student body with different educational backgrounds are not fully realised.

- Admission requirements contribute to the lack of students from disciplines other than Statistics. Rather than requiring that potential students pass an admissions exam, admissions should be based on more general criteria. Instead, students should be required to pass a qualifying exam approximately one year into the program.
- Graduation rates appear to be unacceptably low. This is likely due to the emphasis put on the thesis component of the program, as most students seem to successfully complete the course component. The new program, to begin this semester, must include at least an additional semester of course work and de-emphasise the thesis component.
- Research problems undertaken by the students seem to be dominated by theory. Good methodological work is challenging and so is good research. Most students work outside the university and have real problems to work on. Furthermore, the Extension Service in the Department is a source of interesting problems. There have been 34 graduate students who have obtained their Master's degree since its creation. It is interesting to find out that only 5 among all the theses were applied. The theoretical approach has been the general rule, especially in the areas of Non-parametric Statistics (5), Time Series(6) and Experimental Design and Linear Models (5). This has been partially the reason for such low graduation rates.
- The use of computers should be emphasised in both course work and research. To facilitate the inclusion of computing as an integral part of modern statistics, the computational facilities in the Department need to be extended and modernised.
- Even though the UNC has another graduate program (Specialisation) with less theoretical requirements and more emphasis on methods, the recommendations remain appropriate for a masters program designed to serve both students planning to proceed to an advanced degree and those who will function as professional statisticians outside the University.

Additional discussion

Completing the recommendations given by the Evaluation Committee, training in consulting is also needed, especially for those students interested more in statistical methods than in statistical theory. Graduate students should be encouraged to participate in interdisciplinary projects and work more closely with other professionals. Hunter (1981) pointed out that more than helpers or leaders, statisticians must play the role of colleagues:

> *"The two roles of helper and leader are characterised by one-way communication, the helper receives, the leader transmits. The role of the colleague, on the other hand, necessarily involves two-way communication, and hence makes possible what, for me, is the joy of being a statistician: working on and learning about many different problems, and sharing with clients the excitement of solving those problems*"(Hunter, 1981, pg. 73).

3. SURVEYS ANALYSIS

Three different surveys were designed to learn the opinion of the staff of the Department of Mathematics and Statistics, and non-statistician researchers who have become familiar with statistics methodology through their projects. The analysis of these

surveys is a second source of information concerning the statistics formation given by the University, the main problems that people as users of statistical techniques have to face, and the statistical areas of interest in everyday work

3.1. STUDENTS' SURVEY

A survey of 11 newly graduated and senior year students was analysed. 41% of the statistical applications used corresponded to the area of experimental design. Almost all the rest of them were on non-parametric statistics and sampling designs (approximately 25% for each area).

The use of other statistical techniques was much less frequent and in these cases no big difficulties were encountered in the solution of the problems. This means that most of the consulting tasks carried out by the students was concentrated on hypothesis testing and estimation problems.

There were pathologic cases where the student was asked to analyse some inconsistent and arbitrary data, collected with no scientific methodology at all. At the beginning the student required help from a faculty member, especially to define the analysis strategy to identify and carry out the methodological conditions of the designs. As the student gains experience, he/she also gains criterion independence to solve the cases. He/she learns to identify the errors in the design and in the information, provided by the consultant users, and to propose alternative solutions.

What is clear from the students' survey is that to teach statistical consulting skills seems to be a necessity. Belli (2000) mentions two essential aspects to be taken into account, both related to the experience which must be based on real data and is obtained only through practice.

3.2. RESEARCHERS' SURVEY

Fifteen researchers from different disciplines at the university (psychology, meteorology, chemistry, physics, engineering, medicine, anthropology and biology), familiar with statistical methodology and methods were surveyed to learn their opinion with respect to three main topics. These are: Statistical areas more often used, general preparation in statistical methodology given by the University in the different programs, and the main difficulties related to statistics encountered in their research work. All the researchers have graduate studies at masters or Ph.D. levels.

The utilisation of statistical techniques referred to the different areas is quite diverse. Most of the researchers use two or more tools of this type. However, the most frequently used are Linear Models and Experimental Design. Despite the lack of specialised software, Non-parametric techniques, Sampling and Multivariate Analysis are also required.

The general preparation in statistical methodology given by the university is considered satisfactory by most of the interviewed professionals. This means that the academic level of the statistical courses is good, allowing the students, by themselves or with a consultant's aid, to develop successfully the statistical part of their research work.

With respect to the statistical difficulties, it seems that the researchers usually look for the statisticians' help once the research has advanced, especially when the work demands the definition of analysis strategies or the use of statistical computation. Very often the difficulties persist to the end of the research. This situation is similar to that

one presented by Belli (2001) where she states that most clients look for help once the data have been collected. The ideal situation seems to occur when the consultants are asked to participate from the beginning rather than when asked to salvage an experiment:

> *"In any investigation the planning, what data are collected, and the analysis depend on the objectives of the study, and the statistician needs to be aware of what these are, and to be involved as a member of the research team from the start"* (Jolliffe, 2001, p. 364).

3.3. DEPARTMENT OF MATHEMATICS AND STATISTICS' STAFF SURVEY

Most of the department of mathematics and statistics' members interested in research and/or consulting were surveyed. The main conclusions are drawn from the twelve questionnaires that were returned. More than half have to deal with consulting rather than research itself. Experimental design is the most consulted area, with almost 40% of the requirements.

The researchers, who ask for help, have a proper conceptualisation of the problem and correct handling of methodological aspects. The difficulties arise with data analysis and interpretation, even if the responsible groups are, supposedly, well prepared. One third of the studies were described as very limited in analytic strategies, computing technique usage and interpretation of results.

Designs of surveys and sampling have less demand, however they involve more difficulties throughout the different research phases. These have to do with the definition and operational aspects of the variables, analytic strategies, management and choice of the methodology, and processing and interpretation of final results. Almost all these problems are present in more than half of the consulting cases.

Most of the errors described by Godino et al.(2001), related to doctoral theses on mathematical education, are also present in the research work carried out by professionals in our country. Those associated to the experimental design, variance analysis and sampling techniques are most frequent.

It is also important to mention that, in general, difficulties appear more often with social type research than with research devoted to technical or pure scientific problems.

4. CONCLUSIONS

The students are exposed to a lot of theoretical concepts but they are not involved with real data as often as desirable. Additionally, there is no culture of teamwork. Only in a few courses are students asked to carry out statistical tasks in a group. Besides, there are not sufficient interdisciplinary activities that allow students to share responsibilities concerning the thesis or monograph of their academic programs, under advisors' supervision. For all of the above reasons the students usually feel insecure when they have to face a real problem during their senior year or as recent graduate.

On the other hand, the government education investment on Computing hardware and software has not been sufficient. Usually the acquisition of new machines and programs takes longer than expected. This often makes statistical applications go behind statistical theory.

Some of the existing limitations make some of the best students feel frustrated because they are not motivated towards research. This is especially true for those students who want to continue on a graduate program

Finally, many of the users of consultant services do not have statistical "culture". This leads to consider the statisticians as "helpers" for the statistical analysis rather than as colleagues.

5. RECOMMENDATIONS

The first thing to do is to create a Statistics Lab to provide a sufficient amount of real data for all the applied courses, not only for the undergraduate but also for the graduate programs. This requires to improve the computing hardware and software.

It is necessary for the Department of Mathematics and Statistics to establish closer contacts not only with other departments within the University but with off campus institutions and industries. It is important to undertake joint research and publishing. It is only through this kind of work that the statistical profession gets credit (Ospina, 1991). This task has already begun with the former chairman of the statistics program and now the new chairman has given it a fresh impulse.

This will increase the interdisciplinary work and will give the opportunity to work with real data. Additionally, some research projects could be developed, thus fulfilling, some of the needs of undergraduate and specially, graduate students. To reach this, a serious commitment of some faculty members towards the students is needed in order to form researchers.

Although there is an increasing demand in statistics, it is satisfied usually in a somewhat poor way, by some commercial rather than professional firms. It is important, then, to make the information directed to all the services provided by the Department available to as many people as possible. This will allow the consulting service to strengthen and provide a host of important data with which to work. Notwithstanding, a policy to collect payment for this service should be established.

The consulting service must be offered to more people outside the University. Also, a cycle of seminars or lectures on statistical methodology should be offered to non-statistician professionals, those interested in research, to prevent these people from making some well known and serious mistakes (to collect data in an improper way, to ask for statistical conclusions when the statistical analysis has been wrong, etc.). The untimely statistical assessment must be avoided. Otherwise, there is a risk of considering the statistician as an "expert to correct methodological mistakes", rather than a professional in the discipline.

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