Teaching Statistics in the first years of the University with emphasis in the solution of problems

Elena T. Fernández de Carrera
Facultad de BioquÌmica y Ciencias BiolÛgicas.
Universidad Nacional del Litoral
Paraje El Pozo- Ciudad Universitaria CC 242
3000 Santa Fe Argentina
ecarrera@fbcb.unl.edu.ar

1. Introduction

Nobody doubts nowadays that all professionals should be qualified to design an investigation, gather data with previous planning and analyse the results, he also finds indispensable to be able to understand the current scientific literature. To be able to carry out all this he/she should have knowledge of Statistics. In general, it happens that the students or the graduates of some university careers face themselves before a barrier of numbers, formulas, calculations and mathematical reasoning. Statistics is not easy to learn, on the contrary, it is rather difficult. Statistic is a curious amalgam of mathematics, logic and judgement. Although many are put off by the mathematics, the logical processes are often the ones that cause more difficulty (Altman, 1997). In general the problem becomes worse if this happens especially with those whose careers belong to the Health or Biomedical sciences.

It is not discussed that the principles and Statistical methods are necessary not only for understanding, but also for the effective exercise in any profession, especially those that are related to the health, since the variability of the clinical, biological and laboratory data, either on individuals or communities, that to come to a decision goes always accompanied by a degree of uncertainty. This is due to the undeniable probabilÌstic nature of the Biomedical Sciences and it is in fact the Statistics is the one that provides the appropriate tools to confront the differences and that uncertainty. (Leiva, Carrera, et al, 1999). The Statistics knowledge and of their procedures allow the student and the graduate to critically appreciate the phenomena that happen to their surroundings; it allows him to understand scientific works and to produce his own ones, besides generating data of quality and knowing about the problems that affect the population under study.

Today, any citizen needs in his daily activity certain resources of the Statistics. In

the last years this has taken to radically changed the teaching of Statistics in many of the countries where it is part of the Mathematics curriculum. It is necessary that the citizen learns earlier to interpret the facts that happen to his surroundings and the data that he receives permanently through any means of diffusion. Learning Statistics is nowadays unquestionably based by the instrumental contribution that this science carries out (Gal and Gardfield, 1997). Besides through statistical education researches, the Statistic has been shown as a 'modern discipline', useful to develop in precise form the abilities required in the global world and the information society . (Ottaviani, 1999)

That had motivated the next words of Susan Starkings (1996): "Mathematical education has radically changed, in many countries, over the last decade The need for mathematically literate students who can function in today's technological society has instigated a change in the content of Mathematics curriculum". From the last educational reformation our country has recently begun to introduce emphasis in Statistic with emphasis in the pre-grade curricula. Some years before only charts were given, means and standard deviations and in some cases some other position measure.

3. Teaching goals

In the post secondary versions of introductory Statistics courses, one of the most important goals of its learning is to know the coverage that the contribution of Statistics makes in the construction of the knowledge of specific areas of each career; the student's training to carry out the conversion of this knowledge to situations that frequently demand the use of statistical procedures and the training to read and interpret the publications of other areas of its career understandingly.

3. Our methodological proposal

To reach the objective that we intend it is necessary to:

Emphasis on data analysis because it provides the key of the initial comprehension of the problem. This makes feasible to explore data so as to be able to extract the maximum possible information from them, and a posteriori, go on to a inferential stage. It is necessary to allow 'data to speak'. The current availability of instruments and statistical software with possibilities of graphic representation and treatments of varied data gives a singular importance to the exploratory analysis of data. The didactic possibilities of this are due to the simplicity of the required mathematical apparatus, to the importance given today

to the statistics and to the connections with other topics of the same career. (Batanero, Estepa y Godino, 1992).

The importance of including the techniques of data analysis in the secondary education it has been pointed out many times (Burrill, 1996; Starkings, 1996; Batanero, et al, 1992; Gal and Gardfield, 1997). In the careers like Engineering, the Biomedical Sciences and other sciences that would form part in a great classification of experimental sciences, the exploratory analysis of data, allows to detect outliers or in the case of the careers in Sciences of the Health, biological patterns that can be impairing when beginning future investigations and also not thinking wrong measurements and consequently do something to which we are quite accustomed, to erase them.

In addition, through the analysis of data, and with the support of the computational means, one has a good visualisation of them and it takes it naturally out of the generalised idea that everything is symmetrical, that the behaviours are normal and that the mean and the standard deviation are measures that describe any group of data efficiently. The exploratory analysis of the data is also necessary because in it we find the base, afterwards accompanied with the notion of probability, of the inference process.

The necessity to achieve a balance between two positions in certain antagonistic way is set out. On one hand, the one that bases the teaching -learning process in the mathematical aspects of the construction of the statistical knowledge. On the other hand, that praises the use of the instrument, without the necessary understanding of their foundation. In most of the cases, the first position leads to a loss of the student's interest, future user, due to the excess of mathematical contents and not to sum up his need for a quick application. Furthermore, the second position, on the other hand, leads to an use and abuse of the tools with consequences in risky inferences. To be able to find a balance point between these postures is difficult and complicated. Mainly at this time where the easy access to the use of commercial software of statistical analysis and the availability of powerful computers makes that the researches of other fields, apply those programs directly. When not being well statistically advised and with a formation only of some statistic course, the users use this programs without previously carrying out an analysis of the data they are able to count on, or thinking about the best form of carrying out their analysis, or the validity of the test to apply.

It is necessary to familiarise the student, of any level, with concepts that should be perfectly understood when he finishes their course of Statistic. These

concepts are among those of variability and uncertainty. All together with the bias concept , with all their later implications. Nevertheless, these and other concepts become simpler of apprehending if the access to the understanding of each thematic unit generates in the student the need to solve some problematic situation related with the main curricular axes of their careers.

The importance of the probability:

It is necessary that the student acquires the fundamental knowledge of the probability calculation; and be introduced to the inductive reasoning characteristic of the statistical inference, recognizing the probability as supporting this reasoning.
With appropriate handling of the data analysis and a clear understanding of the meaning of the probability, of their conceptual essence, of the implications between the probability definitions a priori and a posteriori, their teaching and the learning of the inferential statistics is also much quicker and more effective. Naturally in this way they understand the error meaning, level of trust, bias and estimator among others. The calculation of probabilities is the only available mathematical model that seeks to understand what is ignored and what is uncontrollable. Fortunately, this model is at the same time extraordinarily powerful and very comfortable (Mandelbrot, 1993). Probability can be applied as directly as simple arithmetic to reality, it provides an excellent opportunity to show the students how apply mathematics to real problems and how it can become trained with a heuristic and active methodology. (Godino, Batanero y CaÒizares, 1991)

4. Problem Solving

Before speaking of the solution of problems in Statistics it is necessary to point out that Education in Statistics and the investigation of the problem it causes, cannot be separate. Teaching and Research are a couple that is not convenient to separate, mainly in the university level, because the problems detected in the learning of a topic in which students are being trained take us to the systematic curiosity and this to the intellectual innovation. Solving problems, a work methodology that today is not only customary for the mathematicians, but also for the social sciences, has its base in the 'doing', in the 'building'. This building is a continuous process of intuition, discovery, justification, error, backtracking, starting again, finding the appropriate way and at last be successful after working hard or perhaps in the end not to be successful. Besides as a great difference with the problems in mathematics many statistical problems do not have a single mathematical solution. Rather, realistic statistical problems usually start with a

question and culminate with the presentation of an opinion that may have different degrees of reasonableness (Gal and Gardfield, 1997).

The statistics, is presented then as something good to carry out this constructive process that is in fact the solution of problems. According to Ottaviani (1999) the problem solving consists of encouraging the students to solve a problem that enlarges their knowledge by means of the analysis of a particular situation, the formulation of a project, the collection of information, the interpretation of the data, hypothesis verification and the generalization of results. Evidently when solving a problem we are assessing in our students not only the reached result or the applied knowledge, but the process, the activities, the creativity, the aptitudes and it is for this reason that the statistic class is an excellent opportunity to learn how to solve problems but this is not exclusive of the mathematical or statistical class, but rather in them the situations are presented.

The problems that are solved, either motivational as those that begin a learning situation or application problems, so that the students solve them 'thinking', should refer to realistic questions or situations. The traditional methods of teaching statistics usually qualify as ineffective because they are not able to establish a clear relationship between the Statistics and its uses in the real world (Yilmaz, 1996)

In this motivation stage, as well as in other later stages of solving problems it is important the visualization, that is to say the visual impact. By means of the visualization an image is associated to a concept, to a problem and the light seems to begin guiding us to arrive to an abstraction, in the case of a concept to the solution in the case of a problem. Visualization is fundamental so that the imagination begins to work, since the visual representations allow, sometimes, to abstract a concept more efficiently that its verbal description. (Carrera, E., 1999). In the visualization the computer is shown as the ideal assistant. That is why, it should not be thought like a simple tool, but rather as a powerful auxiliary in several stages of the problem solution.

5. A proposal

All these considerations have taken us to write a little book that is in printing. We have been motivated to write it by the belief that most introductory texts do not explain adequately the concepts that underlie the whole subject of statistics, and in many cases they are divorced from the reality. This book should provide and understanding of the principles and concepts that underlie in data analysis and the interpretation of results. Real data have throughout been used in it, mostly

from published papers, and we have tried data that are interesting in their own right. This book should be continued later with the inferential part, although there are already some very good ones.

6. The assessment

It is evident that this teaching approach also requires challenges in the way of evaluating. It can no longer stay in the classic form of repetitive exercises and questionnaires with simple answers like 'yes or no' or 'right or wrong'. It requires questions where the student reveal to understand the main statistical concepts of the problem, the key ideas, the big ideas, to interpret a problem and to choose the appropriate statistical tools that are more adequate to the data. It also requires that anybody can read the paper, understand it and why not carry out critical observations of the same one.

Acknowledgement
The author wishes to thank specially Professor Liliana E. Contini for her helpful for the redaction this manuscript.

References

Altman, D (1997). *Practical Statistics form medical research*. Chapman and Hall. London.

Batanero, C.; Estepa, A. Y Godino, J. (1992). An·lisis exploratorio de datos: Sus posibilidades en la enseÒanza secundaria. *Suma*, 9, p 25-31

Burrill, G. (1997). Curriculum issues in United States Schools. *Papers on Statistical Education*. IASE. Swinburne University of Technology. Australia. p 15-26.

Carrera, E. (1999). La educaciÛn a distancia y la articulaciûn enseòanza media universitaria. El caso de la Educaciûn Matematica. Acerca de la distancia. *Rueda. Eudecor SRL*. Argentina.

Gal, I. and Gardfiel, J. (1997). Curricular goals and assessment challenges in Statistics Education. *The Assessment Challenges in Statistics Education*. IASE. The International Statistical Institute. The Netherlands. p 1 - 13.

Godino, J., Batanero, C., Caòizares, L. (1991). Azar y probabilidad. *Editorial SÌntesis*. Madrid

Leiva, M.; Carrera, E.; Bottai, H.; Contini, L.; Vaira, S. (1999). EstadÌstica en la

formaciûn de grado y postgrado en las Ciencias Biomèdicas. CLATSE V (V *Congreso Latinoamericano de Sociedades de EstadÌstica*). Mendoza, Argentina.

Mandelbrot, B. (1993). Los objetos fractales. *Barcelona. Tusquets*, Eds.

Ottaviani, M. G. (1999). Notas sobre los desarrollos y perspectivas en Edicaciûn EstadÌstica. Conferencia inaugural de CLATSE V (*V Congreso Latinoamericano de Sociedades de EstadÌstica*). Mendoza, Argentina.

Starkings, S. (1997). An international overview of dates analysis within the mathematics cuurriculum. *Papers on Statistical Education*. ICME-8, IASE. Swinburne University of Technology. Australia. p 7 - 13.

Yilmaz, M. (1996). The Challenge of teaching Statistics to non-specilists*. Journal of Statistics Education*. p 4-1 (http://www2.ncsu.edu/pams/stat/info/jse).