TEACHING STATISTICS IN SECONDARY SCHOOL. AN OVERVIEW: FROM THE CURRICULUM TO REALITY ®

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Statistical education and general Mathematical education has changed in Argentina in the last decade. The same has happened in many other countries in the world because the need for students to have a satisfactory Statistical training is an important preoccupation in today's information society. Any citizen, not only scientists and technologists, needs to understand the information available. Although changes already exist in the secondary school Mathematics curriculum, the results are not visible in the university classroom where the students' knowledge of statistics or probability are almost none. This paper describes the results of a survey about the previous knowledge of Probability and Statistics in university students before a first and formal statistical course is carried out. The experience was made among students in the geographic area in Argentina namely Litoral area. We try to identify the reasons why teachers tend to teach descriptive Statistics only, a few elements of Probability and nothing of data analysis.

INTRODUCTION

In the year 1994, a reform in the educational system took place in Argentina. The traditional primary and secondary teaching was modified into Basic General Teaching (EGB in Spanish) and Polimodal Education. In turn the EGB was divided in three cycles: EGB1, EGB2 and EGB3. Age distribution for each of the stages and the binding force are indicated in Table 1:

Table 1 *Current Educational System in Argentina*

Level	Initial	EGB 1	EGB2	EGB3	Polimodal
Ages (years)	5	6 to 8	9 to 11	12 to 14	15 to 17
Compulsory	Yes				No

Starting from this reformation, EGB cycle contents involving data analysis (frequency counting) and graphic interpretation (bar and pie charts, pictograms) are being introduced up to the Polimodal level, where Probability and their Distributions will be taught. Stochastic thought has arrived to all the curricula levels. Considering Table 1, twelve years have passed during which the possibility of incorporating these topics does exist as well as the opportunity of confronting students with the concept of uncertainty, so common for the ordinary citizen that even mass media use it. Thus, the question *Does school prepare them to be able to know these concepts?* arises This not only happens in Argentina but also in many countries round the world, where education has been challenged in the last years. The need for mathematically literate students who can function in today's technological society has instigated a change in the content of mathematics curriculum (Starkings, 1997).

Besides, probability occupies an important place in Science development. Learning Statistics is nowadays unquestionably based on the instrumental contribution that this science carries out. (Gal & Gardfield, 1997). Nobody doubts nowadays that all professional should be qualified to design an investigation, gather data with a previous planning and analyse the results, he/she 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 (Leiva et al., 1999). Such learning should be done in earlier and earlier stages. Being probabilities intuitive and important for the analysis of problems and simulation, they present certain difficulties for the teachers when looking for motivating problems for the students and that allow them to elaborate ideas before arriving to the general theory. (Carrera et al., 1998)

With the use of the computer as a tool to calculate and to visualize, a great quantity of theoretical and practical problems can quickly be worked out. The problem-solving as methodology as well as teaching through them have advanced in all the Secondary curriculum subjects. Constructivism invades the educational publications. Computers also facilitate

introducing students to simulation, that is, placing them in a context that imitates some aspect of reality, and establishing similar situations to those that they will face in their personal life. (Carrera et al., 1997). This is a way of stimulating their creative and independent attitude, allowing them to accelerate the learning process and also to achieve a higher quality. 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)

It is well-known that Mathematics language is not simple, but the possibility that the students incorporate it should be given as it can be useful even in their future behaviour when they have to solve a real life problem. Sometimes, the mathematical language is more appropriate and simpler, however it is not unimportant that the students apply their common sense when they solve a problem (Batanero, 1999). As echoing Mr. M. de Guzmán (1999) says when he refers to the current situation in Education:

> "There are clear examples in our current elementary teaching education of which I would like to mention one. Forty years ago it made sense to insist in learning with security and speed to do mental calculation: long sums, multiplications and divisions of big numbers. A strong dedication to this attention and memory exercise was welcomed. Today the situation is quite different. Few adults in our society make long multiplications and divisions with paper and pencil, attention and memory. And however, in most of our schools students continue spending long months in the acquisition of some routines that they will not use. It would be worthwhile to use some of this effort in learning to estimate, approximately, the magnitude of the resulting numbers in order to verify them with the ones calculators provide immediately. The extra effort and the remaining time could be invested in more appropriate and useful things."

It was possible to observe in these experience that students do not have completely formal thought. The answers obtained were so free that in some cases, they distrusted the tendency and used their own cognitive mechanisms when choosing an option, justifying their choice. Although it is not the aim of this work the analysis of each one of the free answers, it is important to rescue this fact, since our educational culture has the tendency to grant space to the formal thought and outlines of structured reasoning and it does not always leave place to the intuitive thing. (de Guzmán, 1999; Carrera et al, 2000).

BASIC CONTENTS OF BASIC GENERAL TEACHING.

According to the Resolution Number 30/93 of the Federal Council of Culture and Education, the National Ministry of Culture and Education published in 1994 (First Edition) the Common Basic Contents (CBC) for the Basic General Education (EGB), which were the fundations for the curricula designs of each jurisdiction since 1995. CBC organization of Mathematics for the EGB has been arranged in 8 blocks:

Block 1: Number
Block 2: Operations
Block 3: Graphic and algebraic language
Block 4: Geometric notions
Block 5: Measurements
Block 6: Statistic and Probability Notions
Block 7: Procedures related to Mathematics
Block 8: General attitudes related to Mathematics

Blocks allow integrations and interconnections by selecting topics that integrate different approaches. There must always be a link between Blocks 7 (Procedures) and 8 (Attitudes) and blocks 1 at 6 whose numeration is completely arbitrary. Thus, the teacher decides what to teach and in what order to teach it (MEC, 1994). The block that interests, is in fact block 6 whose achievements are: To know how to gather, organize, process and interpret information statistically, and to understand, estimate and use probabilities, valuing these procedures for decision making. The contents in the Third Cycle of the EGB goes from elementary notions about population and sample, measurement scale, data representation in charts, graphics and their

interpretation; measurement of central trends and variability. Probability: classic (technical counting included) and frequency approach, properties. Random variables.

Students should conclude their compulsory basic formation with those achievements. They will surely be enlarged with the Polimodal contents, cycle that should necessarily approve before going into University. Then the question arise *Do the students that indeed study Statistics and Probability in their University courses have that knowledge?* These students, from Engineering, Biotechnology and Biochemistry *have they acquired such formation that would imply changes in the contents of the Statistics subject in the University?* To answer these questions and having in mind that from previous years the answers had been negative, an experience was programed with the aim of analyzing students' previous knowledge and to tests the following working hypothesis: The university students do not have systematic previous knowledge neither of statistics or probabilities, but they do have an intuitive knowledge.

DESIGN OF THE EXPERIENCE

During the years 2000 and 2001, 207 university students were given a questionnaire. The total sample was divided into two groups of students according to the career chosen. One, (n=156 students) was of Civil and Electronic Engineering of Paraná city, influencing the east of the Litoral region; a second group of Biotechnology and Biochemistry students (n=51) in the city of Santa Fe, influencing the west of the Argentine Litoral. Students ages ranged from 18 to 22 years.

SELECTION AND CONSTRUCTION OF THE INSTRUMENT

Seven articles of David R. Green's "Test Probability concepts and 11-16 years old pupils" were used to elaborate the questionnaire. They were taken from the notes of the Probability Didactics Course held by Dr. Carmen Batanero in Argentina, 1999. With these articles the proportion of students with knowledge of Probability were assessed and the justification in the answers given were incorporated so as to detect errors in their reasonings. In this way it was determined if they had formal or only intuitive previous knowledge. Besides, students were given questions to see if they had studied some topics of Statistics during their EGB and Polimodal courses.

DETAILS OF THE INSTRUMENT

Question 1: Application of the classic definition of probability.
Question 2: Identification of random events. True or False according to trends.
Question 3, 4, 5 and 6: Empiric distributions. Identification of the most probable event for the falling of balls through different channels.
Question 7: *A posteriori* Probability. Frequency approach of probability definition.
Question 8, 9 and 10: Aimed to know what items of Descriptive Statistics, Data Management (simple) and Theoretical Distributions (normal) students had dealt with in the EGB and Polimodal. According to the results of this survey and the students' comments, and to analyze the attitude and behavior of the Mathematics teachers at Secondary School when facing the new Statistics curricular contents was carry out.

INTERVIEW: CASE STUDY AND INSTRUMENT DEVELOPMENT

Six teachers of Mathematics were selected for doing this case study. They teach in secondary schools of the Argentine Litoral Region, two of them are University professors and one is doing postgraduate studies in Mathematics. They were informed of the survey type and its purpose and all of them agreed to fully collaborate. In the survey their Academic Degree, Age, Number of weekly hours devoted to teaching and also if they teach in their courses Probability and/or Descriptive Statistical, if they had studied these topics in their career and if they had attended some updating course. In Addition, two problems involving the concept of Statistical Independence and Stochastic Sequence (Batanero, Bernabeu et al., 1995; Serrano et al., 2001) were also included.

RESULTS AND DISCUSSION

Students questionnaire: In Table 2 percentages of right answers of the instrument of the groups of students are presented according to specialty, year and region. If necessary to found the independence between the specialty and performance. *P*-values concerning chi-squared contrast was calculated and used to compare the proportions among each group of students.

Table 2 *Rates of right answers of the Five Groups of Students*

	East Litoral Región				West Litoral Region	
	2000		2001			
	Civil Eng. (n=27)	Electrónic Eng. (n=36)	Civil Eng. (n=33)	Electrónic Eng. (n=60)	Biotechnology (n=51)	P-Value
P1	0.259	0.361	0.485	0.400	0.451	0.407
P2	0.556	0.694	0.576	0.517	0.608	0.438
P3	0.593	0.75	0.515	0.650	0.333	0.001*
P4	0.407	0.722	0.515	0.517	0.314	0.004*
P5	0.704	0.778	0.606	0.783	0.804	0.264
P6	0.556	0.667	0.424	0.517	0.451	0.247
P7	0.148	0.028	0.182	0.100	0.000	0.193**

* Statistically significant, $\alpha = 0.05$

** p-value associated with the four first groups comparison, since West Litoral Region group had no (0) correct answer.

Question 7 showed the lowest percentage in correct answers. It was >20% in any group. This question was intended to evaluate the knowledge regarding the frequency approach to the probability concept concerning their applicability in the careers were attending. Even more, they could not identify the most probable event. The second question showing no more than 50% of correct answers is question number 1, referred to the classic probability concept application. Questions 3, 4, 5 and 6 are similar, and so it was expected that that the percentage of correct answers would be rising from question 3 onwards. In questions 3 and 4 statistically significant differences were found, however one could say that the proportion of correct answers for questions 5 and 6 are homogeneous. This indicates that Students have not followed a systematic reasoning in their answers, mainly within the Biotechnology group that paradoxically presents the minimum and the maximum proportion of correct answers in these four articles.

Question 2 referred to Random Sequence and was correctly responded, oscillating between a minimum 51% and a maximum 72%. When analyzing the justifications we found that about 35% of the answers were properly done, without using formal developments but only intuitive reasoning. With regard to the second part of the instrument (Questions 8, 9 and 10) where topics referring to Descriptive Statistic were incorporated as well as knowledge of distributions we found that 82% of the students accepted to have learnt bars and pie charts during the EGB and Polimodal, 22% only studied some histograms, 6% frequency polygons, a surprising 10% stem-leaf diagrams and approximately 5.2% studied normal distribution. Regarding descriptive measures about 27% studied arithmetic mean and median, 20% the range and 41% of the students answered "no descriptive measure".

Teachers' Interviews: The results of the six teachers showed that only two taught, partially, the Curriculum contents. Another three neither studied these topics in their career nor took updating courses in topics related to Probability or Statistics. For that reason, they avoided including those topics in their classes. From here, it was found that they have confused ideas about Randomness and Independence. This may be due to diverse causes. Among them the lack of clear and precise concepts, flaws in their degree formation, or may be that these topics were not presented to the students in previous years and now they have forgotten these concepts.

CONCLUSIONS

The outcome offers evidence that students arrive to their first course of Statistics and Probability in the University with almost null systematic studies of the elementary concepts of probability. Nevertheless, they have developed some worth intuition in some cases. This allows us to conclude that secondary education does not prepare them adequately to face problems that involve this concept, and mainly that of uncertainty. Teachers' interviews confirm that most of them in Secondary level are not teaching the topics they should, according to the Educative Reform. It is also clear that it is necessary to offer teachers that have been on duty for some years the opportunity to do updating training in Probability and Statistics. As regards Teaching Training Courses it is necessary that they give Probability and Statistics the place that they should occupy nowadays. This conclusion is exactly the same as Anne Hawkins (1996). She said "… it requires more than a modicum of statistical training for people to be sensitive to the sloppy, misleading and frankly incorrect reporting of statistical information, rather than being merely passive assimilator of its style…" (p. 61).

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